Aerospace Materials and Processes Technology Reinvestment Workshop

WRIGHT LABORATORY

18 & 19 May 1993
Ervin J. Nutter Center
Dayton, Ohio

Aerospace Materials and Processes Technology Reinvestment Workshop

Wright Laboratory Materials Directorate's
Aerospace Materials and Processes Technology
Reinvestment Workshop

Tuesday 18 May 1993

0730-0830	Registration	
0830-1030		
0830-0840	Welcome	Mr Scott Theibert
0840-0910	Purpose	Dr Vincent Russo
	Overviews	
0910-0930	Air Force	Air Force Materiel Command
0930-0950	DOD	Mr Jerome Persh
0950-1010	ARPA	Dr Ben Wilcox
1010-1030	NIST	Dr Lyle Schwartz
1030-1100	Break	
1100-1130	Status of Current Activities	Mr Jerry Covert
1130-1230	Examples of Current M&P Partnerships	
1130-1150	IHPTET Fiber Consortium	Mr Stephen Strunck - GE
1150-1210	Modeling of Casting Flow and Solidification	Dr Thomas Tom - Howmet
1210-1230	Intelligent Design of Aluminum Extrusion Processes	Mr Butch Dyer - Tech Dev Corp/YSU
1230-1400	Lunch	Nutter Center
1400-1540	Industrial Perspectives	Aerospace Industry
1400-1420	Northrop	Mr Allan Freedman
1420-1440	Lockheed	Mr Bill Hargrove
1440-1500	MCAIR	Mr James Dorr
1500-1520	Pratt and Whitney	Dr Bill Yee
1520-1540	Westinghouse Science & Technology Center	Dr Dick Hopkins
1540-1600	Break	
1600-1700	Industrial Perspectives (Cont)	Suppliers & Industry Associations
1600-1620	NCAT/AIA	Mr Richard Hartke
1620-1640	QuesTech Research Division	Mr Ned Maurer
1640-1700	National Automotive Center - US ARMY	Capt Richard Brynsvold
1700-1830	No Host COD Bar	Nutter Center

Wednesday 19 May 1993

0830-1000	Potential Topics for M&P Partnerships	Air Force
0830-0850	Introduction and Objectives	Mr Larry Hjelm
0850-0930	Metals and Ceramics Division	Dr Norm Tallan
	Metals, Intermetallics and MMC	Ms Katherine Williams
	Ceramics	Dr Allan Katz
	Metal and Ceramic Material Processing	Mr Jim Morgan

	Nondestructive Evaluation	Mr Charles Buynak
0930-1010	System Support Division	Mr Tom Cooper
	Pollution Prevention & Repair Mat'ls & Processes	Mr Ted Reinhart
	Aging Aircraft & Failure Analysis/Prevention	Mr Ron Williams
1010-1030	Break	
1030-1210	Potential Topics for M&P Partnerships (Cont)	Air Force & Others
1030-1110	Nonmetallic Materiais Division	Dr Charles Browning
1110-1140	Electromagnetic Materials & Survivability Division	Mr William Woody
1140-1210	Integrations and Operations Division	Mr Robert Rapson
1210-1300	Lunch	Nutter Center
1300-1630	Adjourn for Specialist Sessions/Discussions	All
Berry Room 1	Metals and Ceramics Division	
Berry Room 2	Nonmetallic Materials Division	
Berry Room 3	Electromagnetic Materials & Survivability Division	
Room 240	System Support Division	
Room 226	Integrations and Operations Division	

DR. VINCENT J. RUSSO, DIRECTOR

AIR FORCE OVERVIEW

Aerospace Materials and Processes Technology Reinvestment Workshop

Dr. Vincent J. Russo, Director
Materials Directorate

MATERIALS DIRECTORATE
MISSION

Plan and execute the USAF programs for materials and processes in the areas of basic research, exploratory development, advanced development, and manufacturing research. Provide systems support to Air Force product divisions and operating commands to solve system related problems and to transfer expertise in the areas of materials, processes and manufacturing.

MATERIALS DIRECTORATE
PHYSICAL PLANT

- ESTIMATED BUILDINGS REPLACEMENT VALUE — $94,400,000
- ESTIMATED SCIENTIFIC EQUIPMENT REPLACEMENT VALUE — $122,200,000
- LABORATORY MODULES — 209
- TOTAL AREA — 379,000 FT^2

MATERIALS DIRECTORATE
MATERIALS & PROCESSES
EXPERTISE IN ML FACILITY

	TOTAL	MS	PhD
GOVERNMENT			
SCIENTISTS & ENGINEERS	229	123	70
TECHNICIAN	9	-	-
OTHER	43	-	-
SUBTOTAL	281	123	70
OTHER			
NRC POST DOCTORATE FELLOWS	11	-	11
ML VISITING SCIENTISTS PROGRAM	36	6	26
INTERGOVERNMENTAL PERSONNEL ACT	2	-	2
ONSITE CONTRACTOR PROFESSIONAL S&E	118	35	49
ONSITE CONTRACTOR SUPPORT/TECHNICIAN	95	6	-
COLLEGE STUDENT SUPPORT	43	1	-
SUBTOTAL	305	48	88
TOTAL	586	171	158
PERCENT OF S&E WORKFORCE (396)		41%	40%

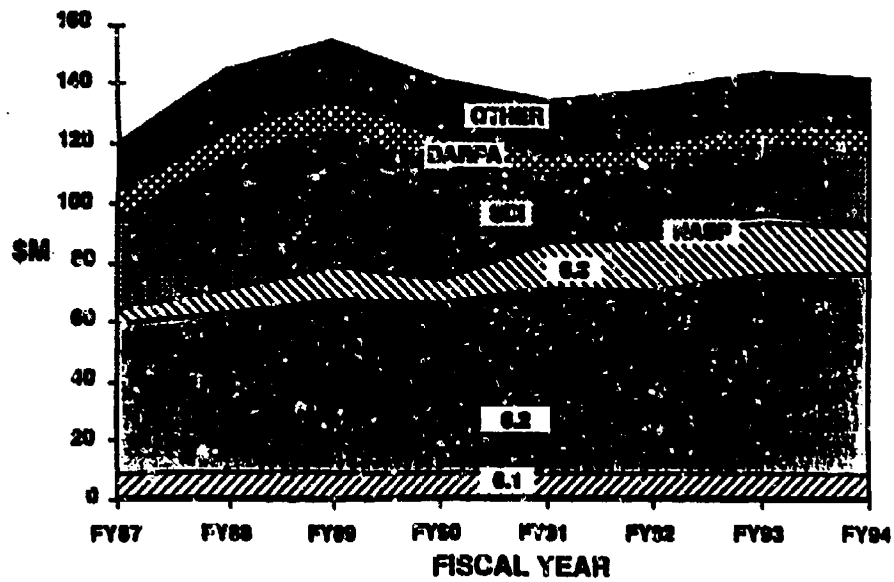
MATERIALS TECHNOLOGY AREA PLAN

MAJOR THRUSTS

THRUST TITLES	METALS & CERAMICS	NONMETALLIC MATERIALS	ELECTRO-MAGNETIC MATERIALS	SYSTEMS SUPPORT	INTEGRATION AND OPERATIONS
1 CARBON - CARBON & THERMAL PROTECTION MATERIALS		☆			
2 METALLIC MATERIALS	☆				
3 NONMETALLIC STRUCTURAL MATERIALS		☆			
4 NONDESTRUCTIVE EVALUATION	☆				
5 CERAMICS & VERY HIGH TEMPERATURE METALLICS	☆				
6 NONSTRUCTURAL MATERIALS		☆			
7 ELECTRONIC & ELECTRO-MAGNETIC MATERIALS			☆		
8 LASER HARDENED MATERIALS			☆		
9 MANUFACTURING RESEARCH					☆
10 SYSTEMS SUPPORT				☆	

MATERIALS TECHNOLOGY AREA PLAN

FINANCIAL TREND



DEFENSE CONVERSION
AND
THE AFMC ROLE

DEFENSE CONVERSION HISTORY

1980, 1986	Congress requires Federal Laboratories to transfer technology to State/Local Governments and the private sector
1992	Congress establishes Defense Conversion Commission, appropriates \$1.5B for defense conversion programs -- \$575M for Defense Conversion Initiatives
1993	President announces reorientation of Defense R&D -- Civilian R&D to increase from 41% in 1993 to 50% by 1998 (+ \$8.7B)

TECHNOLOGY TRANSFER ACT OF 1986

* Made technology transfer a responsibility of all federal lab S&Es
* Created financial incentives through royalty sharing
  - At least 15 percent to federal inventor
  - Remainder to inventor's organization
* Created the Federal Laboratory Consortium (FLC)
* Empowered lab directors to enter into Cooperative Research and Development Agreements (CRDAs)

DEFENSE CONVERSION, REINVESTMENT AND TRANSITION ASSISTANCE ACT OF 1992

* Major Congressional initiative to promote Dual-Use Technologies
* Appropriates $1.5B in FY 93
  - $575M directly applicable to defense technology and industry programs
* DoD is OPR for most activities
* Implementation policy not yet formulated

BUSINESS PRACTICES REQUIRED

- Simple non-adversarial agreement/partnership mechanism
- Clarity and flexibility for intellectual property rights
- Conflict of interest guidelines for non-adversarial partnerships
- 2371 U.S.C. 10, Cooperative Agreements
  - Delegated authority, maximum flexibility

TRANSITION AGREEMENTS AUTHORITY

New Law - 10 U.S.C. 2371

- What does it do?
  - Authorized "cooperative agreements and other transactions"
  - For "advanced research"
- Why?
  - Procurement contracts are best suited for buyer/seller relationships
  - R&D often involves support, stimulation, cooperation
  - Flexibility and innovation required
  - Impact of government funding is often more like investment than the purchase of goods and services

A TOP LEVEL METRIC

"ALL LABORATORIES MANAGED BY .... DOD WILL BE REVIEWED WITH THE AIM OF DEVOTING AT LEAST 10-20% OF THEIR BUDGETS TO R&D PARTNERSHIPS WITH INDUSTRY"

President William J. Clinton
22 Feb 93

MR JEROME PERSH

DEPARTMENT OF DEFENSE

THE DEPARTMENT OF DEFENSE
MATERIALS AND STRUCTURES
SCIENCE AND TECHNOLOGY PROGRAMS

AEROSPACE MATERIALS AND
PROCESS REINVESTMENT WORKSHOP
AIR FORCE WRIGHT LABORATORY MATERIALS DIRECTORATE

MAY 1993

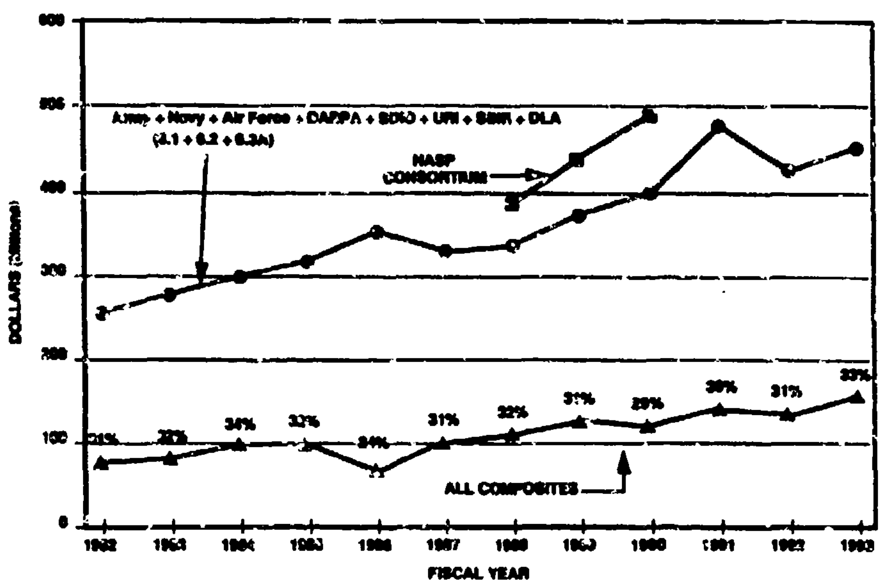
JEROME PERSH
STAFF SPECIALIST FOR
MATERIALS AND STRUCTURES
OFFICE OF THE DIRECTOR/ADVANCED TECHNOLOGY

ODDR&E/ADVANCED TECHNOLOGY (AT)

DOD MATERIALS AND STRUCTURES SCIENCE AND TECHNOLOGY SUMMARY

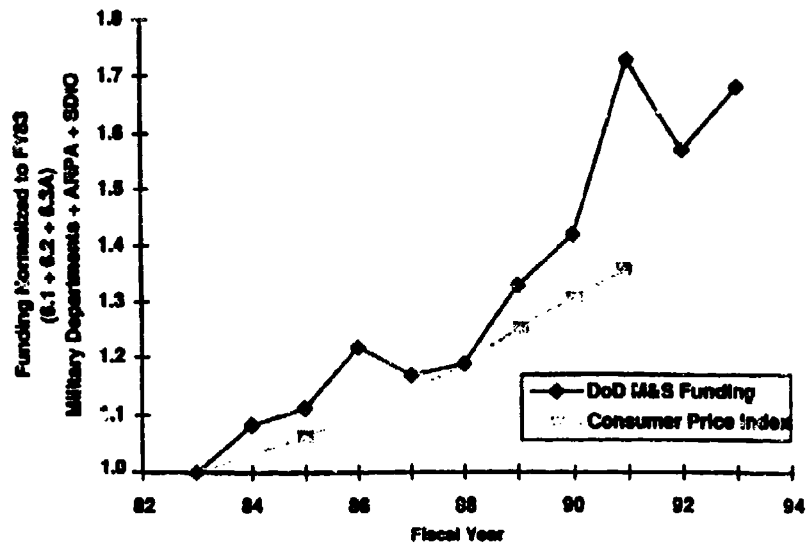
- THE DoD IS SPENDING ALMOST 1/2 B/YR FOR MATERIALS AND STRUCTURES RESEARCH AND DEVELOPMENT (6.1 + 6.2 + 6.3A)
  - OF THIS TOTAL, 1/4 TO UNIVERSITIES, 1/2 TO INDUSTRY, 1/4 IN-HOUSE
- RESEARCH AND DEVELOPMENT INDUSTRY BASE HEALTHY
  - CHALLENGED
- PARTICIPATION BY SMALL COMPANIES (SBIR), UNIVERSITIES (6.1, URI), LARGE AND SMALL COMPANIES (6.2, 6.3A)
- THE AVERAGE ANNUAL GROWTH RATE HAS BEEN ABOUT 10% OVER THE PAST 10 YEARS
  - PROGRAM HAS ALMOST DOUBLED FY 1980 – 1993
- ROUGHLY 1/3 OF THE TOTAL EXPENDITURES ARE ON "COMPOSITES"

DOD MATERIALS AND STRUCTURES SCIENCE AND TECHNOLOGY PROGRAM FUNDING ALLOCATION BY MISSION AREA

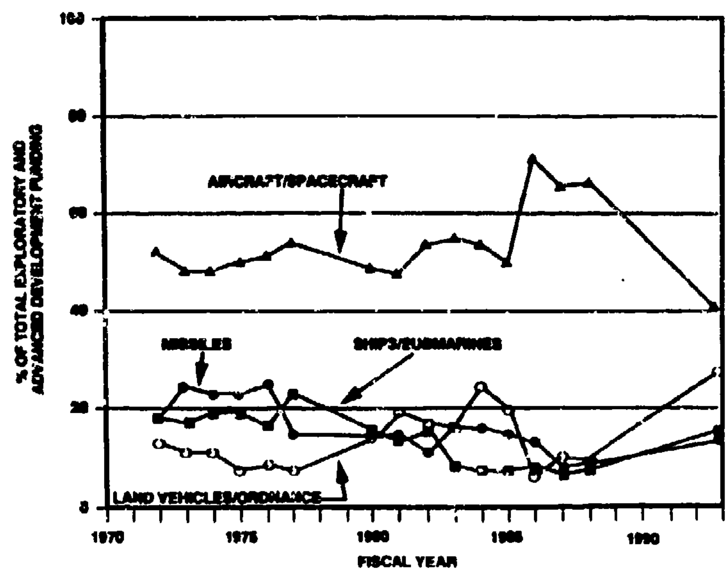


THE DEPARTMENT OF DEFENSE
MATERIALS AND STRUCTURES
SCIENCE AND TECHNOLOGY PROGRAMS

FUNDING HISTORY



DOD MATERIALS AND STRUCTURES
SCIENCE AND TECHNOLOGY PROGRAM FUNDING
ALLOCATION BY MISSION AREA



OBSERVATIONS, DIRECTIONS, AND MORE BOTTOM LINES

- THINGS ARE CHANGING RAPIDLY
  - "BUSINESS AS USUAL" OBE
  - CONSORTIA / PARTNERSHIPS / ALLEGIANCES ARE BECOMING A "WAY OF LIFE"
  - DUAL USE AND ENVIRONMENTAL CONSIDERATIONS BECOMING VERY IMPORTANT
  - CONTRACTING MECHANISMS EXPANDING
- HUGE OPPORTUNITIES FOR LARGE AND SMALL COMPANIES
  - BUT CHANGES NECESSARY
    - VERTICALIZATION
    - COMPANY-TO-COMPANY ARRANGEMENTS
      - INNOVATION SHARING
    - SPECIALTIES CONCEPTS

THE DEPARTMENT OF DEFENSE
MATERIALS AND STRUCTURES SCIENCE AND TECHNOLOGY PROGRAMS

- Defense Conversion/Dual Use is Very Important for the DoD Materials and Structures S&T Community
  - Now and the Foreseeable Future
  - Appreciable Funding
- Challenge is to Propose Programs that Satisfy Both Military and Civilian Needs
  - Management Concepts (Partnerships, Consortia, Integrations/Government Labs, States, Universities, Local Jurisdictions, etc.)
  - Technical Excellence
  - Build on Existing Technology
  - Short-Term Focus

BOTTOM LINES

- THE ADMINISTRATION AND THE CONGRESS RECOGNIZE THE IMPORTANCE OF ADVANCED MATERIALS TO WORLDWIDE COMPETITIVENESS
  - OFFICE OF SCIENCE AND TECHNOLOGY POLICY (OSTP)/ FEDERAL COORDINATING COUNSEL FOR SCIENCE, ENGINEERING AND TECHNOLOGY (FCCSET)/TECHNOLOGY AND INDUSTRY/COMAT/AMPP
  - SENATE AND HOUSE ARMED SERVICES AND APPROPRIATIONS COMMITTEES
  - SENATE AND HOUSE COMMITTEES ON COMMERCE, SCIENCE, TRANSPORTATION, AVIATION, SPACE, AND MATERIALS
- OVERALL U.S. ADVANCED MATERIALS COMMUNITY (GOV'T, INDUSTRY, ACADEMIA) SOLIDLY SUPPORTED BY U.S. GOVERNMENT (AND MANY STATES)
- U.S. INDUSTRY AND ACADEMIA ARE VERY, VERY STRONG PLAYERS IN WORLDWIDE COMPETITION

THE DEPARTMENT OF DEFENSE MATERIALS AND STRUCTURES SCIENCE AND TECHNOLOGY PROGRAMS

ADVANCED RESEARCH PROJECTS AGENCY (ARPA) ADVANCED MATERIALS SYNTHESIS AND PROCESSING PARTNERSHIPS PROGRAM

CHARACTERIZATION

- State/federal government/industry/academia participation
- Management by partner group/government does not lead
- 50% cost sharing/IRAD + in-kind
- Legal agreements/MOUs by partners
- Partners assume responsibility/accountability
- Intellectual property agreements
- Funding direct/milestone-schedule driven

THE DEPARTMENT OF DEFENSE
MATERIALS AND STRUCTURES
SCIENCE AND TECHNOLOGY PROGRAMS

ADVANCED RESEARCH PROJECTS AGENCY (ARPA)
ADVANCED MATERIALS SYNTHESIS
AND PROCESSING PARTNERSHIPS PROGRAM

- **Concerns**
  - Unfamiliar administrative/contracting procedures/ commercial accounting practices
  - FAR / DFAR / DCAS can be waived
  - Relationship to SBIR / S & T - Reliance unclear
  - Small company participation
  - Competition losers

THE DEPARTMENT OF DEFENSE
MATERIALS AND STRUCTURES
SCIENCE AND TECHNOLOGY PROGRAMS

SUMMARY

- **Future health of materials & structures funding and industrial base becoming dependent on ability of industry to:**
  - Identify high pay-off "dual-use" opportunities
  - Assemble working partnerships
  - Capture fair share of partnership funding

DR. LYLE SCHWARTZ

NIST

THE NEW ENVIRONMENT - NIST IN THE BRAVE NEW WORLD

- Vision and the Technology Plan
- Congressional Lead/Response
- NIST and Other Agencies

VISION AND THE TECHNOLOGY PLAN - 1

- Extramural
  - ATP
  - MEP
  - Quality

VISION AND THE TECHNOLOGY PLAN - 2

- Intramural
  - Laboratory
  - FCCSET
  - Industry (Outreach?)

VISION AND THE TECHNOLOGY PLAN - 3

- Budgets
  - 4 year OMB Passback
  - FY93 Supplement
  - FY94 Request
  - FY95-97

NIST AND OTHER AGENCIES

- Defense Conversion
- FCCSET
- AMPP

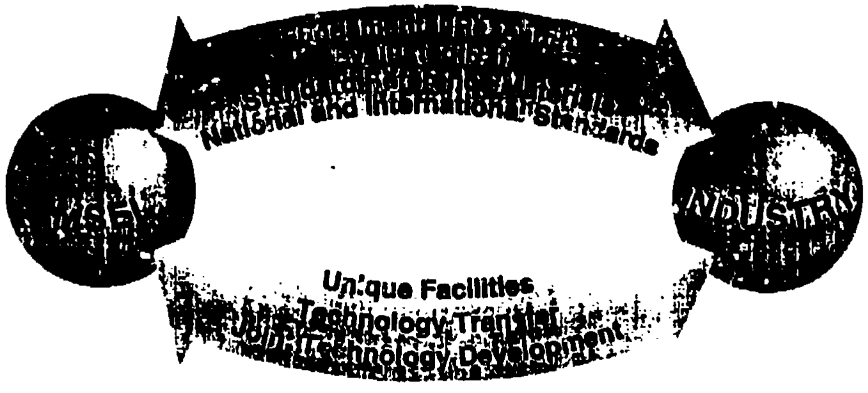
AMPP: THE NIST ROLE

AMPP Technical Components		NIST Programs
Synthesis and Processing Theory, Modeling and Simulation Characterization	⟷	The Laboratories ATP
Education and Human Resources	⟷	MTC
Facilities	⟷	NBSR and CNRF

MISSION

MSEL is the Federal Government's central resource for measurement-related materials research in support of industrial needs and U.S. standards.

MSEL - INDUSTRY INTERACTIONS



PLANNED INITIATIVE EXPANSION
(under consideration)

Name	Cooperating Lab.
Functional Gradient Materials	CSTL
Interconnects	EEEL
Distributed Theory Center	CAML
Nanostructured Materials	CSTL
Machining of Advanced Materials	MEL
Infrastructure Materials	BFRL
Metal Matrix Composites	-
Photonic Materials	EEEL, PL

MR. JERRY COVERT

STATUS OF CURRENT ACTIVITIES

ARPA

Program Information Package
for
Defense Technology Conversion,
Reinvestment, and Transition Assistance

March 30, 1993

Technology Reinvestment—What it Is

<u>Technology Reinvestment is</u>:

(1) Focus on turning technologies into products/processes

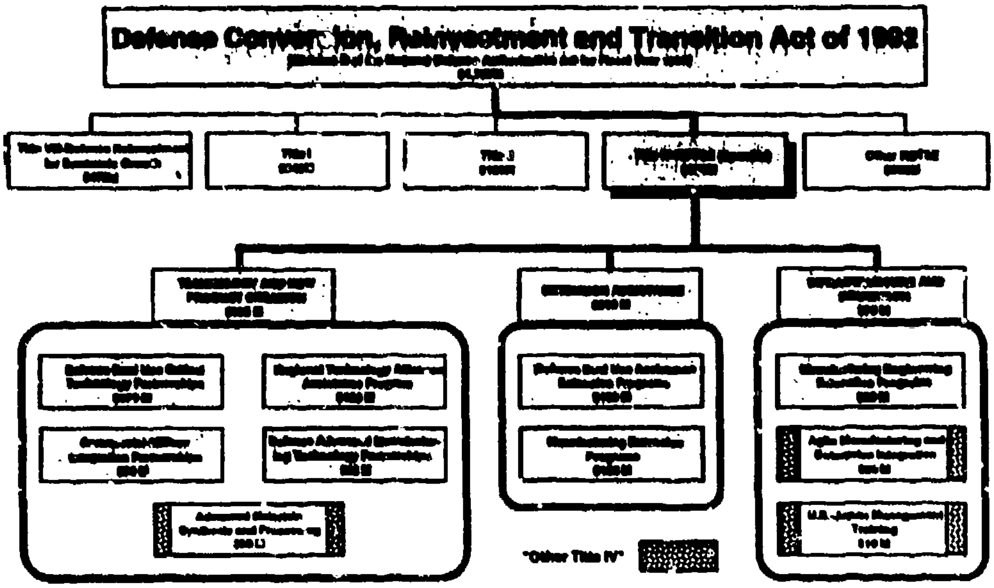
(2) Create jobs in the long term

- Diversification from defense to commercial products
- Integration of defense and commercial production facilities
- Deployment of technology to and from commercial industries
- Development of Dual-Use technologies

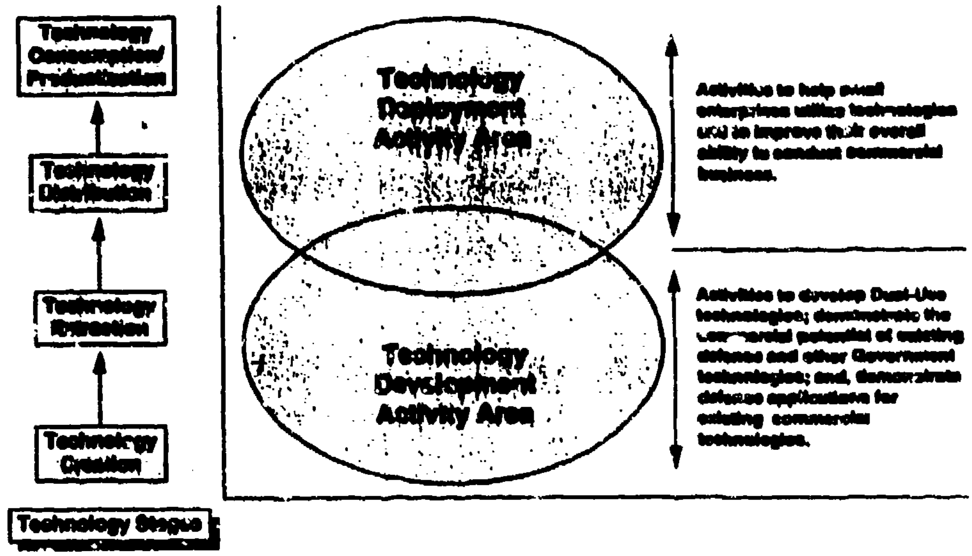
Technology Reinvestment—What it is <u>Not</u>

- *NOT* near term compensation for base closings
- *NOT* extension of unemployment benefits
- *NOT* more support for basic research
- *NOT* Government venture capital
- *NOT* for transition of national laboratories to for-profit
- *NOT* a way to continue defense business as usual

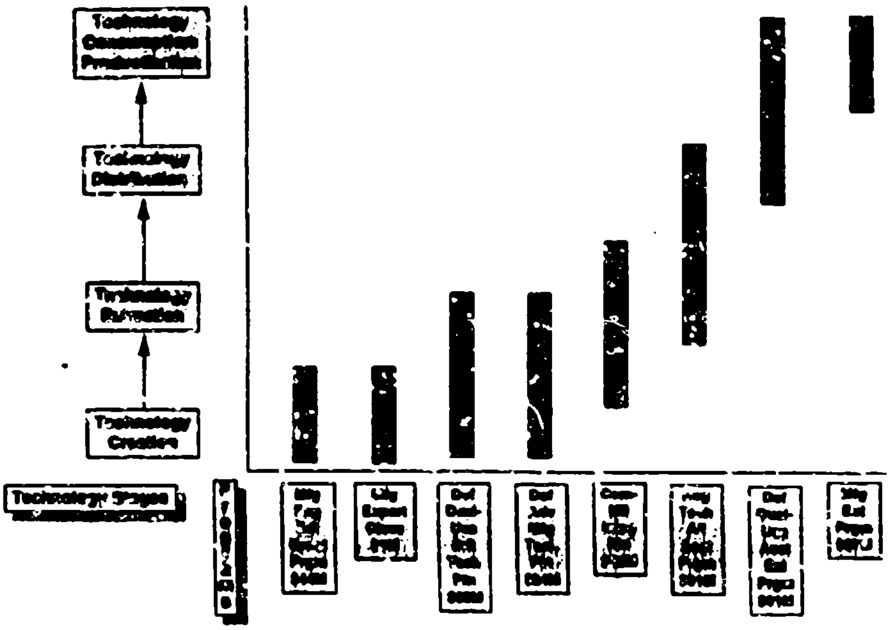
Defense Conversion, Reinvestment and Transition



Technology Stages and Activity Areas



Technology Reinvestment Project Emphases



Common Requirements

Statutory requirements common to all programs

(1) All require competitive award

(2) All contain participation and organizational requirements

(3) All require industry cost sharing of at least fifty percent (50%)

(4) Defense emphasis – 10 U.S.C. § 2501

Technology Reinvestment Project

Mission

To stimulate the transition to a growing, integrated, national industrial capability which provides the most advanced, affordable, military systems and the most competitive commercial products.

Strategy

Invest Defense Conversion, Title IV funds in activities which stimulate the:

1) Development of technologies which enable new products and processes
2) Deployment of existing technology into commercial and military products and processes
3) Integration of military and commercial research and production activities

Technology Reinvestment Activities

- Defense Technology Conversion Council (DTCC) established December 16, 1992
  - Department of Defense (Advanced Research Projects Agency and Military Departments)
  - Department of Energy (Defense Programs)
  - National Science Foundation
  - Department of Commerce (National Institute of Standards & Technology)
  - National Aeronautics and Space Administration
- A single competition is planned for the issuance of a formal solicitation
- Evaluation, ranking, and selection of proposals will be conducted jointly
- Distributed execution

Technology Development

Technology Development activities deal with the creation of new product and process technologies and exploration of their potential for commercial and/or defense applications. Proposals that involve either basic research OR final product development beyond the stage of product prototype/feasibility demonstration will be regarded as out of scope.

- Proposals will fall into one of three activities:

  (1) Spin-Off Transitioning activities are those that demonstrate non-defense commercial viability of technologies already developed for defense purposes.

  (2) Dual-Use Development activities are those that develop commercially viable technologies that have both defense and non-defense uses.

  (3) Spin-On Promotion activities are those that demonstrate the defense utility of existing non-defense commercially viable technologies.

Technology Development Focus Areas

- Information Infrastructure
- Electronics Design and Manufacturing
- Mechanical Design and Manufacturing
- Materials/Structures Manufacturing
- Health Care Technology
- Training/Instruction Technology
- Environment Technology
- Aeronautical Technologies
- Vehicle Technology
- Shipbuilding Industrial Infrastructure
- Advanced Battery Technology

These topics are not to be considered exclusive; the Government will entertain ideas in other areas.

Technology Deployment

Proposals will fall into one of four activities:

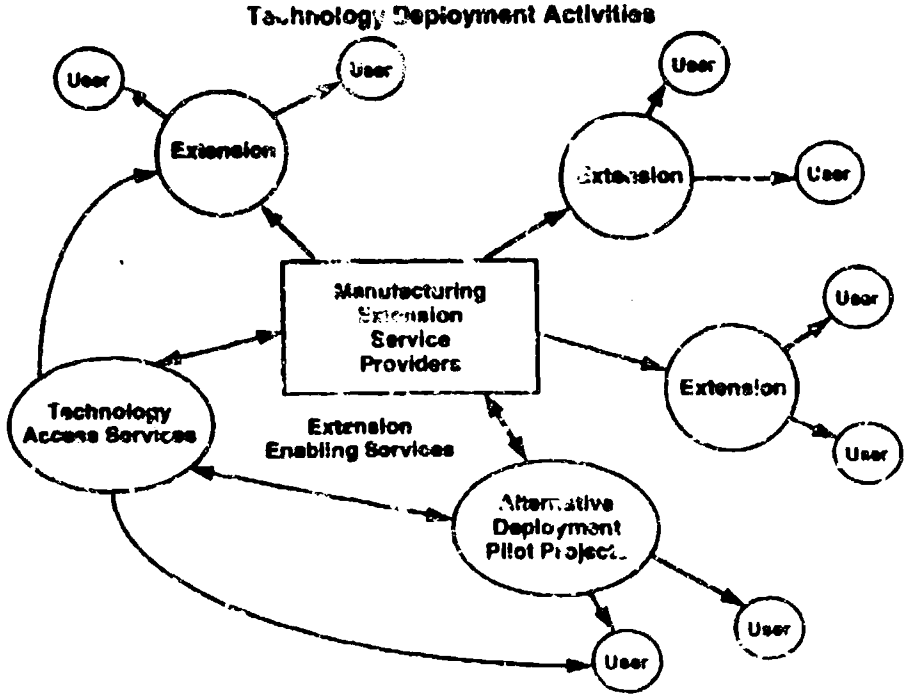
(1) Manufacturing Extension Service Providers target small businesses (fewer than 500 employees) to increase competitiveness through technical and management advancement (restructure business practices, assist with accessing consulting services and technologies).

(2) Extension Enabling Services are activities that link together providers of Manufacturing Extension Service Providers with each other and developers of technology.

(3) Alternative Deployment Pilot Projects are innovative modes of technology deployment that are alternatives to Manufacturing Extension Service Providers.

(4) Technology Access Services are activities to assist the private sector with acquiring existing and emerging Dual Use technologies.

Technology Deployment Activities



Manufacturing Education and Training

Proposals will fall into one of seven activities:

(1) Engineering Education in Manufacturing Across the Curriculum

(2) Practice-Oriented Master's Degree Programs

(3) Retraining the Manufacturing Work Force

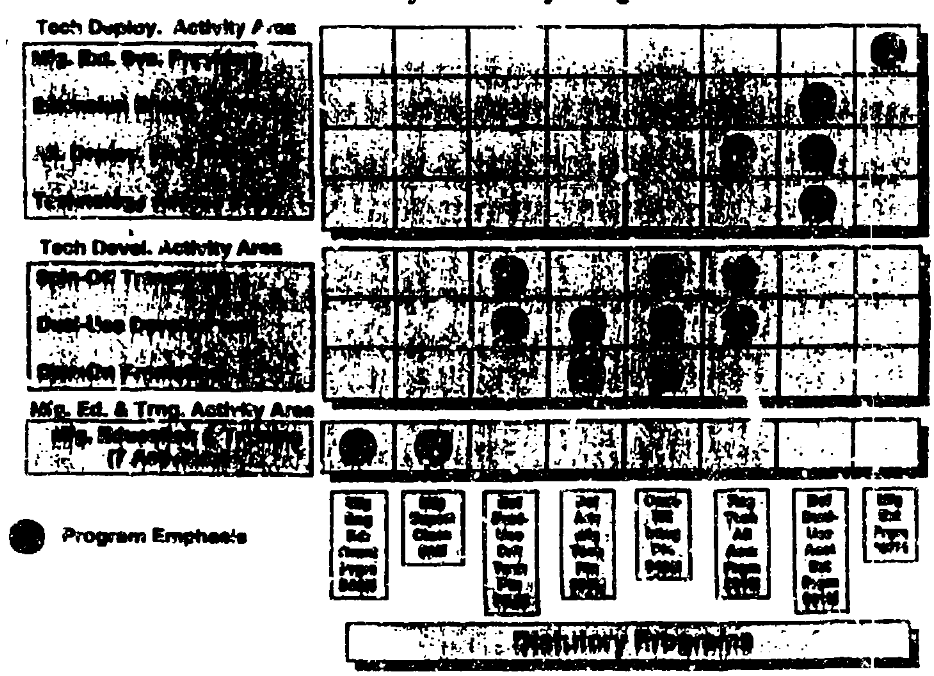
(4) Educational Traineeships for Defense Industry Engineers

(5) Manufacturing Engineering Education Coalitions

(6) Supplementary Education Awards to Ongoing Centers and Coalitions Devoted to Manufacturing

(7) Individual/Group Innovations in Engineering Education in Manufacturing

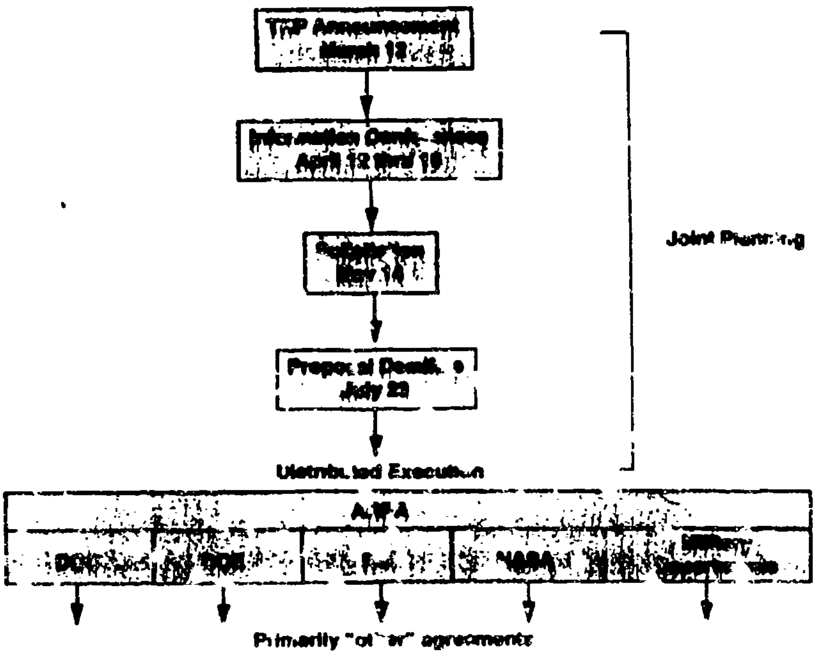
Activities by Statutory Program



Small Business Innovative Research (SBIR)

- Technology Reinvestment Project (TRP) plans to solicit proposals from small businesses
  - Proposals will address technology development focus areas
  - Procurement will be based on Federal SBIR guidelines
- Cost sharing will be permitted for TRP SBIR proposals, but is not required and will not be an evaluation factor
- Out-year TRP activities are a natural SBIR Phase III follow-on

Joint Agency Program



AIR FORCE PAY-OFF

- AFFORDABLE AIR FORCE SYSTEMS
  - LEVERAGE UNIFIED INDUSTRIAL BASE VOLUME PRODUCTION PRICES
- DEVELOP AIR FORCE PROTOTYPE EQUIPMENT AT NEAR 0 COST
- MAINTAIN AIR FORCE INFRASTRUCTURE
  - WITHOUT CHANGE, MUCH WILL BE LOST WITH AF/DOD ONLY INVESTMENT
  - IMPROVED TECHNOLOGY DEPLOYMENT
- ALLOW FOCUSED INVESTMENT ON AIR FORCE UNIQUE TECHNOLOGY

NEW WAY OF DOING BUSINESS

- GOVERNMENT-INDUSTRY-ACADEMIA PARTNERSHIP VIA ALLIANCES
  - PARTICIPATIVE GOVERNMENT INVOLVEMENT (AGENCIES)
  - NO LONGER CUSTOMER-VENDOR RELATIONSHIP
  - EFFECTIVE IN PRE-COMPETITIVE PHASE
- FOCUSED ON DUAL USE TECHNOLOGY
  - BUILDING UNIFIED DEFENSE-COMMERCIAL INDUSTRIAL BASE
  - DEVELOPMENT- DUAL USE PROTOTYPE PRODUCTS
  - DEPLOYMENT- UNIFIED DEFENSE-COMMERCIAL INFRASTRUCTURE
  - EDUCATION- UNIFIED MANUFACTURING EDUCATION & TRAINING

DR. BEN WILCOX

ARPA

PRESENTATION NOT AVAILABLE

MR. STEPHEN STRUNCK

GENERAL ELECTRIC

PRESENTATION NOT AVAILABLE

DR. THOMAS TOM

HOWMET CORPORATION

COOPERATIVE ARRANGEMENTS FOR GENERIC TECHNOLOGIES

BACKGROUND

- DEFENSE ADVANCED RESEARCH PROJECTS AGENCY (DARPA) AUTHORIZED BY CONGRESS ($50 MILLION) IN 1991 TO FORM SIX PRECOMPETITIVE CONSORTIA

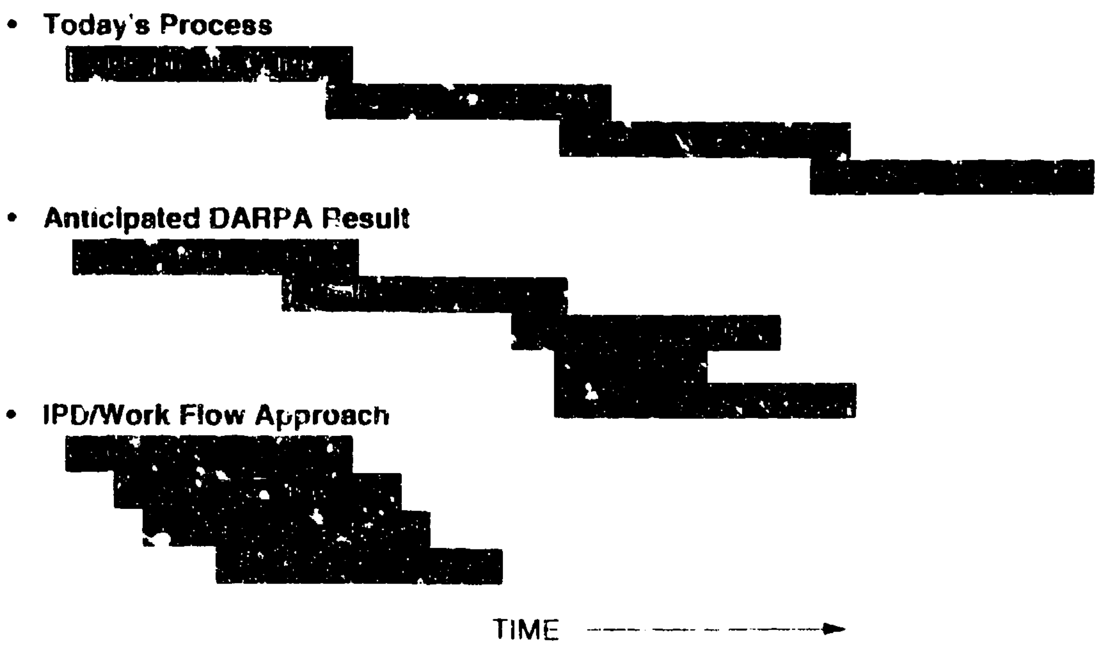
- 1992 CONGRESS HAS AUTHORIZED ($70 MILLION) FOR DUAL-USE PARTNERSHIPS SIMILAR TO 1991 PRECOMPETITIVE CONSORTIA

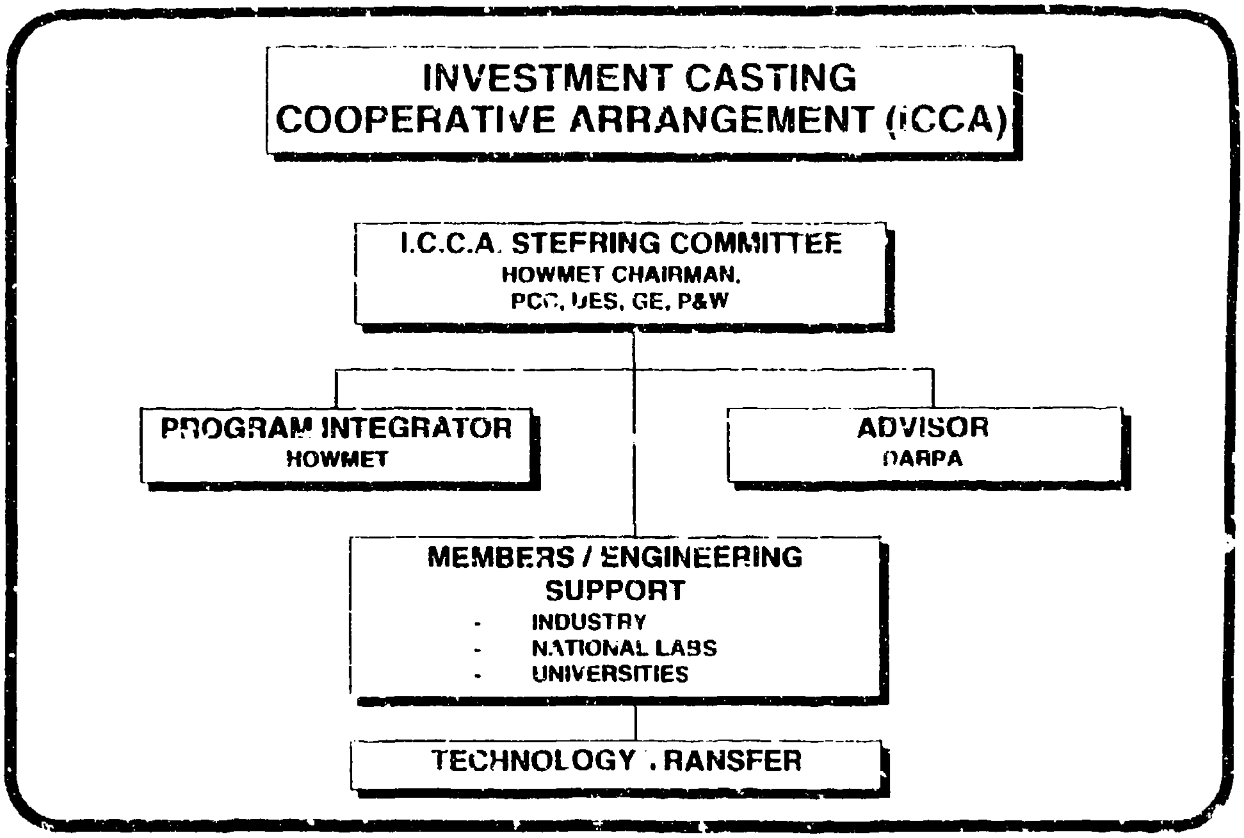
- 7 TECHNOLOGIES SELECTED OUT OF 121 WHITE PAPERS FOR DUAL-USE PARTNERSHIPS

BENEFITS

- Reduced Weapons System Turbine Engine Acquisition Costs - $50 to 100 Million Per Year Achievable
- Improved Airfoil and Structural Casting Quality (Increased Yields), Reliability, and Consistency.
- Greatly Reduced "Time to Market" for Airfoil and Structural Castings (Goal is 50% Minimum).
- U.S. Technological and Competitive Advantages for Both Military and Commercial Applications.
    - Aircraft Turbine Engine Producers
    - Investment Casting Foundries
- Preservation of Product/Process Design Experience and Expertise (Organizational Learning).
- Technology Transferrable to Other US Casting Industries.

BENEFITS OF INTEGRATED PRODUCT-PROCESS DEVELOPMENT





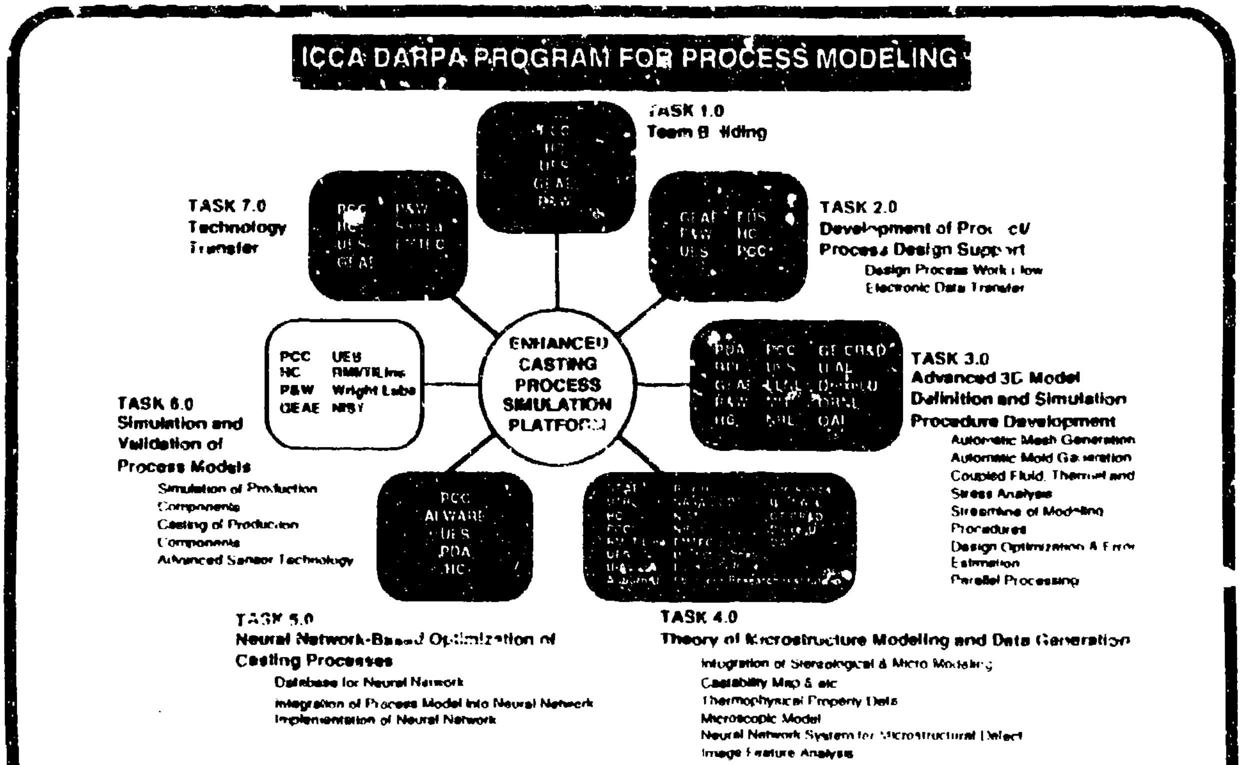


FIGURE 1-6 PROGRAM SCHEMATIC OVERVIEW SHOWING TASKS, PARTICIPANTS, AND RELATIONSHIPS.

INVESTMENT CASTING COOPERATIVE ARRANGEMENT

TECHNICAL PLAN

- EXPECTED ACCOMPLISHMENTS

  - SUPPORTED PLATFORM FOR SOLIDIFICATION PROCESS MODELING WHICH PROVIDES IMPROVED USER FRIENDLINESS AND EFFICIENCY IN MODEL AND SIMULATION

  - VALIDATION OF SOLIDIFICATION MODELING ON PRODUCTION AIRFOIL AND STRUCTURAL CASTINGS

  - DEMONSTRATION THAT INDUSTRY PARTICIPANTS CAN COOPERATIVELY WORK TOGETHER TO PROVIDE AN IMPLEMENTATION STRATEGY FOR COMPREHENSIVE ANALYSIS OF COMPLEX CASTINGS, THERE BY MAINTAINING U.S. COMPETITIVENESS

  - CREATION OF A CASTING INDUSTRY INFRASTRUCTURE FOR CONCURRENT ENGINEERING OF PRODUCT, PROCESS, AND TOOLING WHILE PROVIDING FOR THE FUTURE INCORPORATION OF TECHNOLOGY

PROCESS MODELING

ICCA - ARPA

Howmet, GE, UES, PCC, P&W, ARPA/WPAFB

LLNL CRADA

Howmet
UES
UTRC

CASTNET - NASA

Howmet, Ford Motor, GEAE, Intersonics, UES, DOE, LLNL, Auburn Univ., Purdue Univ., Univ. of Alabama

NIST CONSORTIUM ON CASTING OF AEROSPACE ALLOYS

ICCA
Allison
CTC
GD Space Systems
Teledyne
AFS
Idaho National Eng. Lab
NASA
US Bureau of Mines
Auburn Univ.
Case Western Reserve Univ.
MIT
Penn State Univ.
Univ. of Alabama

PROCESS MODELING

ALIGNMENT OF PROCESS MODELING INITIATIVES

- ICCA ARPA: $ 12M/2 Yrs (50% Cost Share), May 1993 Integrated Modeling Procedure to Reduce Modeling Turnaround Time and Improve Model Accuracy
- NIST: 1.8M / 3 Yrs of NIST Budget Allocated April 1993 Alpha Case Prediction, Metal Mold Contact Conductance, Mold Fill and Solidification Pathway

PROCESS MODELING

ALIGNMENT OF PROCESS MODELING INITIATIVES (Continued)

CASTNET: 1.2M / 3 Yrs of NASA Budget Allocated, January 1993

- Thermophysical Properties, Defect Maps, Contact Conductance, Low Gravity Experiments, and Microstructure Modeling

LLNL CHADA: 1.8M / 3 Yrs of LLNL Budget Allocated, April 1993

- Iterative Solver, Thermal-Mechanical Code, Solidification Kinetics, and Parallel Processing

IPD PHILOSOPHY

- There is only **ONE TEAM**
- **TRUST** is the glue that holds the team together
- Team management is based on **FACT** and **DATA**
- **PROCESS DISCIPLINE** leads to real communication

"requires discipline and process uniformity"

IPD TEAM PROCESS

- Focus on customer's needs and expectations
- Build a Multi-cultural and Multi-functional teams in a complex environment
- Lead a Process-oriented/Mission focused Program
- Identify and avoid non-value-adding work
- Translate tools and techniques into daily activities
- Empower the teams to accomplish specific missions

ICCA (INVESTMENT CASTING COOPERATIVE ARRANGEMENT)

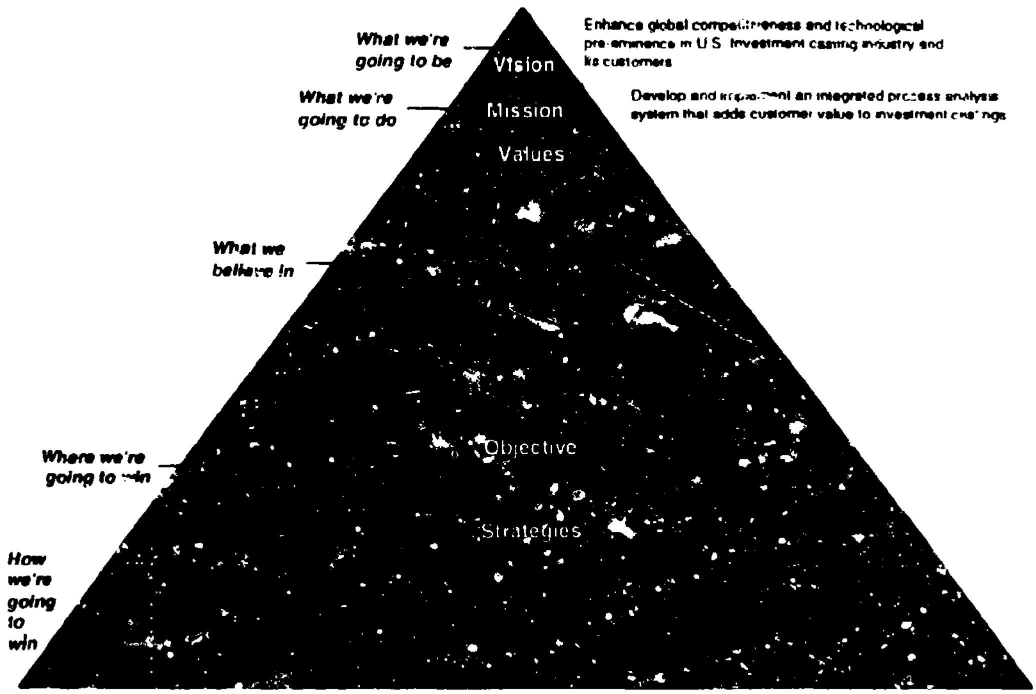


FIGURE 1-7 IPD (INTEGRATED PRODUCT DEVELOPMENT) TEAM PHILOSOPHY FOR ENHANCING INVESTMENT CASTING MODELING TECHNOLOGY AND GLOBAL COMPETITIVENESS

VISION

ENHANCE GLOBAL COMPETITIVENESS AND TECHNOLOGICAL PRE-EMINENCE IN U.S. INVESTMENT CASTING INDUSTRY AND ITS CUSTOMERS

MISSION

DEVELOP AND IMPLEMENT AN INTEGRATED PROCESS ANALYSIS SYSTEM THAT ADDS CUSTOMER VALUE TO INVESTMENT CASTINGS

VALUES

- *TRUSTING TEAM THAT WILL OPENLY SHARE CONTRACTUAL DATA TO SATISFY CUSTOMER NEEDS*
- *INTEGRATED PRODUCT/PROCESS DEVELOPMENT / CONCURRENT ENGINEERING (IPD/CE) IS OUR BELIEF*
- *STRIVE FOR WIN-WIN; COMPROMISE FOR COMMON GOOD (VISION/MISSION) AND DATA BASED DECISIONS*
- *DIALOGUE RESTRICTED TO PRE-COMPETITIVE TECHNOLOGIES (PROPRIETARY INFO - NEED TO KNOW)*
- *FOCUS ON IMPLEMENTATION WHICH IS AFFORDABLE, RUGGED, USER FRIENDLY AND COMMERCIALLY SUPPORTED TECHNOLOGY*
- *EARLY USE RESTRICTED TO U.S. INDUSTRIES*
- *TECHNOLOGY RISKS & REWARDS SHARED (MOST FAVORED CUSTOMER STATUS FOR ICCA MEMBERS)*
- *AVOID NIH SYNDROME*
- *DEVELOP ADVANCED TECHNOLOGY AS-NEEDED*

STRATEGIES

- INCORPORATE TEAM TRAINING TO ENABLE EFFECTIVE TEAMWORK - USE EMPOWERED SUBTEAMS TO MAXIMUM EXTENT POSSIBLE
- USE COMMERCIAL SOFTWARE TOOLS AND INTERFACES TO BUILD AN INTEGRATED PLATFORM FOR FUTURE PROGRAMS WITH ARPA AND/OR MANTECH
- COORDINATE PROGRAM STRATEGIES WITH DOD, DOE, DOC, INCLUDING NATIONAL AND FEDERAL LABORATORIES (SANDIA, NIST, LIVERMORE, WPAFB,NRL, ETC) AND UNIVERSITIES
- DEFINE ACHIEVABLE, MEASURABLE, AND MEANINGFUL GOALS AND MILESTONES
- ACHIEVE CONTINUOUS TECHNOLOGY TRANSFER
- ENHANCE AND VALIDATE EFFECTIVENESS AND EFFICIENCY OF MODELING CODES AND PROCEDURES
- INTEGRATE ARPA FOLLOW-ON PROGRAM(S) INITIATIVES WITH OEM SUPPLIER INITIATIVES
- MAINTAIN PROPER BALANCE BETWEEN DEVELOPMENT AND IMPLEMENTATION TECHNOLOGIES AND AVAILABLE FUNDS
- MAINTAIN PROGRAM FLEXIBILITY TO DIRECT AND REALLOCATE AS NECESSARY AND INDICATED BY FACTS/DATA

OBJECTIVE

TO ACHIEVE DEMONSTRABLE PROGRESS IN REDUCING CYCLE TIME, COST, SCRAP/REWORK THROUGH ENHANCEMENT, VALIDATION AND APPLICATION OF THE SOLIDIFICATION MODELING PROCESS FOR PRODUCTION AIRFOIL AND STRUCTURAL CASTINGS WITHIN AVAILABLE TIME/RESOURCES

COST SHARE

WHAT QUALIFIES AS COST SHARE?

- Relevant In-Kind - Company funded programs completed prior to kickoff
- Concurrent In-Kind - Company funded parallel contributory programs
- Cash

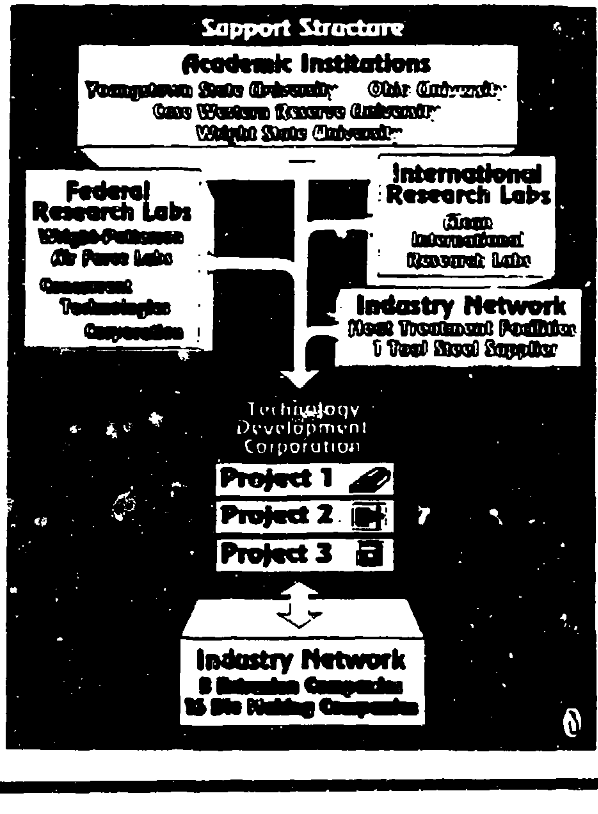
SUMMARY

CRITERIA FOR SUCCESS FOR COOPERATIVE ARRANGEMENTS

- Individual who represents a company must be flexible, team player and results oriented
- Leader / chairperson of steering committee must be a good listener, fair and consistent
- Establish trust between all team members
- Establish & obtain buy-in to overall missions & values of the program
- Establish frequent lines of communications between all team members

MR. BUTCH DYER

YSU-TECHNOLOGY DEVELOPMENT CORP.



ALUMINUM EXTRUSION NETWORK OF THE GREATER MAHONING VALLEY, INC.

HISTORY

MID–1990: PROPOSAL SUBMITTED TO THE OHIO DEPT. OF DEVELOPMENT FOR NETWORK SUPPORT.

- 11 EXTRUSION COMPANIES
- 50+ SUPPORT BUSINESSES

MAR 1991: YSU–TDC ASSIGNED AS TECHNICAL SERVICE. PROVIDER AND HELD FIRST NETWORK MEETING.

- 5 EXTRUSION COMPANIES

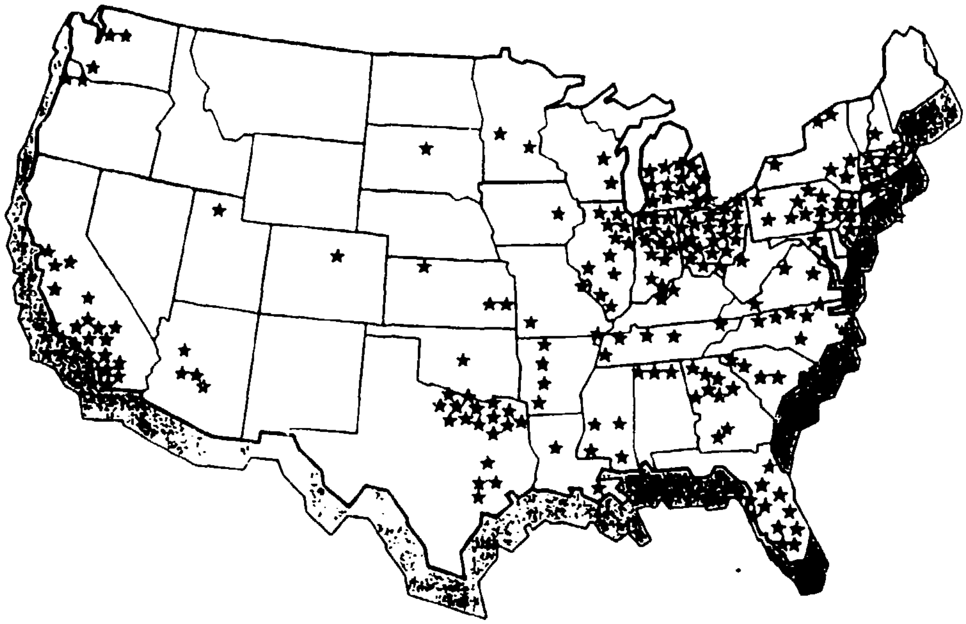
FEB 1992: TOOL & DIE MAKERS HELD FIRST MEETING.

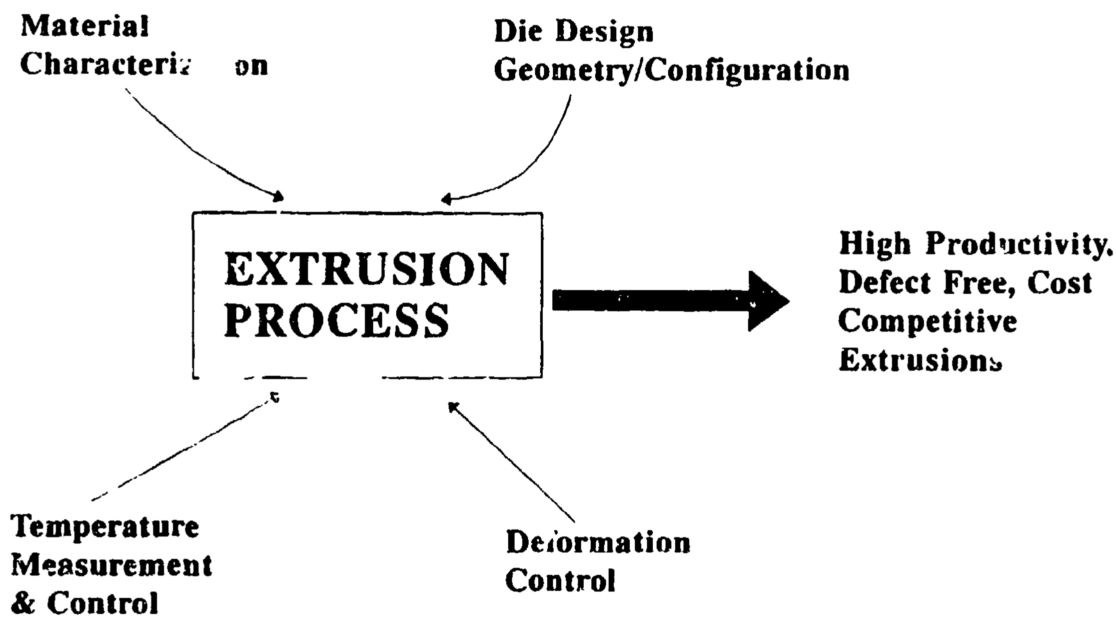
- 16 TOOL & DIE MANUFACTURERS

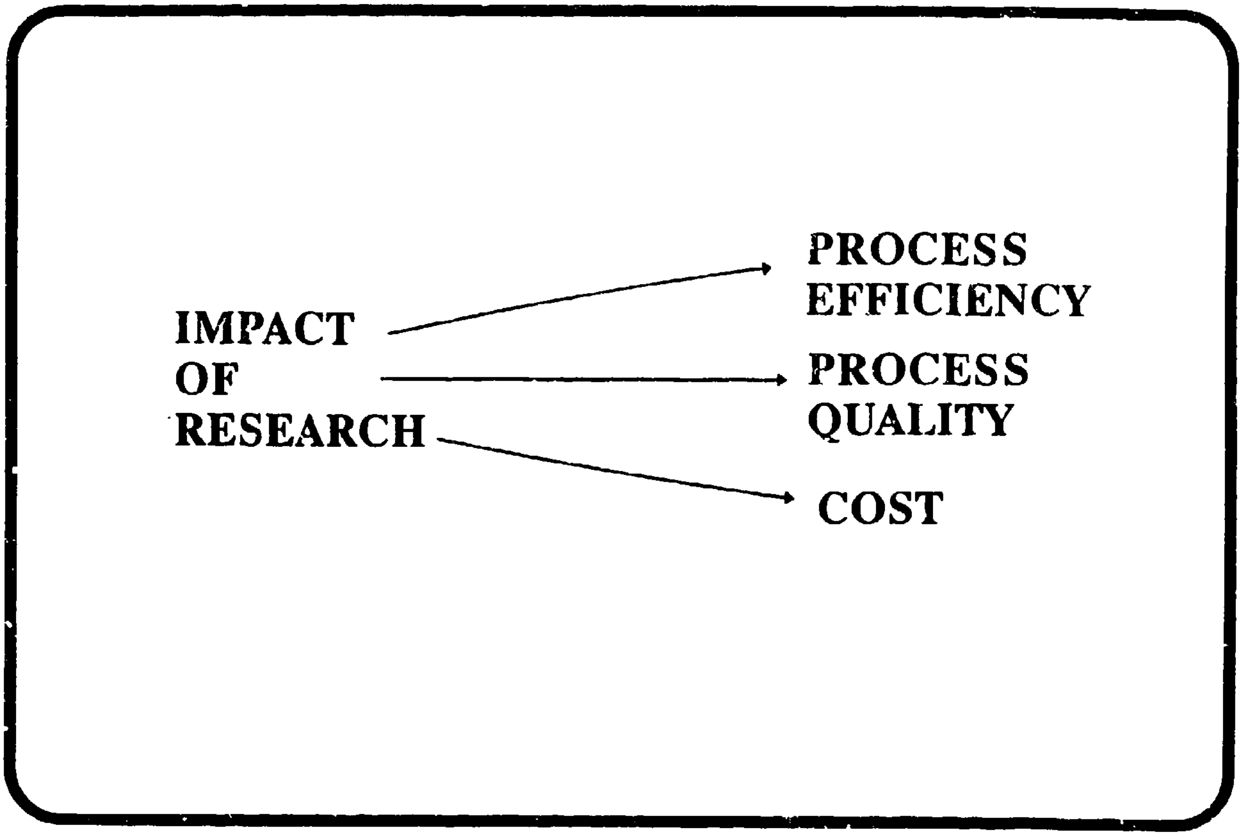
NETWORK ACTIVITIES

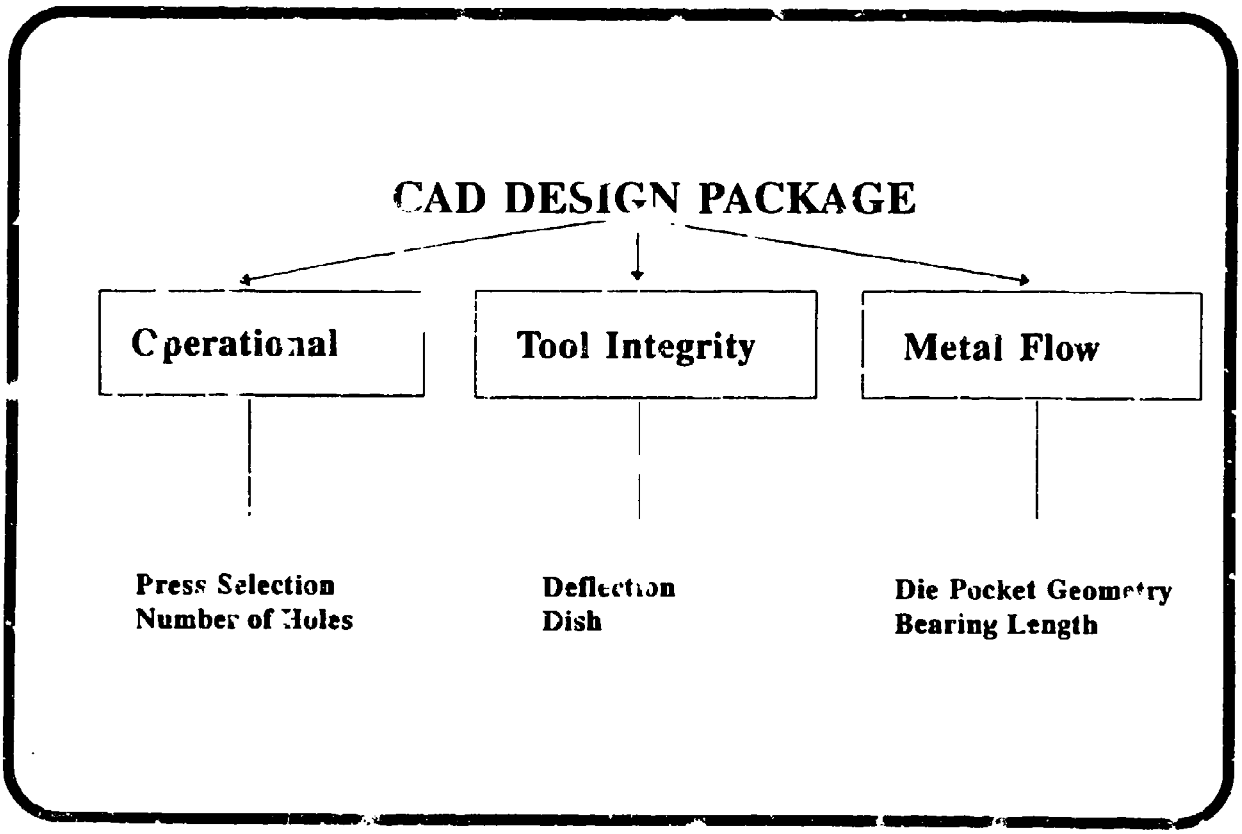
- RESULTS ORIENTED
- 95% CONTROLLED BY NETWORK
- CAD/CAM TECHNOLOGIES
- TQM/ISO 9000
- SURFACE CORROSION
- WASTE MINIMIZATION
- INCREASED DIE LIFE
- IMPROVED HEAT TREAT TECHNOLOGIES
- SKILLS ENHANCEMENT
- TECHNICAL DATABASE
- PROCESS CONTROLS
- GROUP BENEFITS

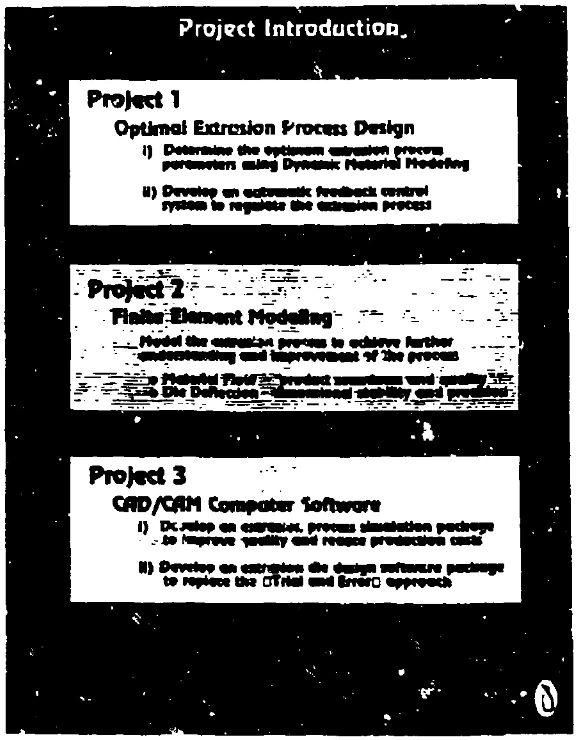
DISTRIBUTION OF U.S. EXTRUDERS

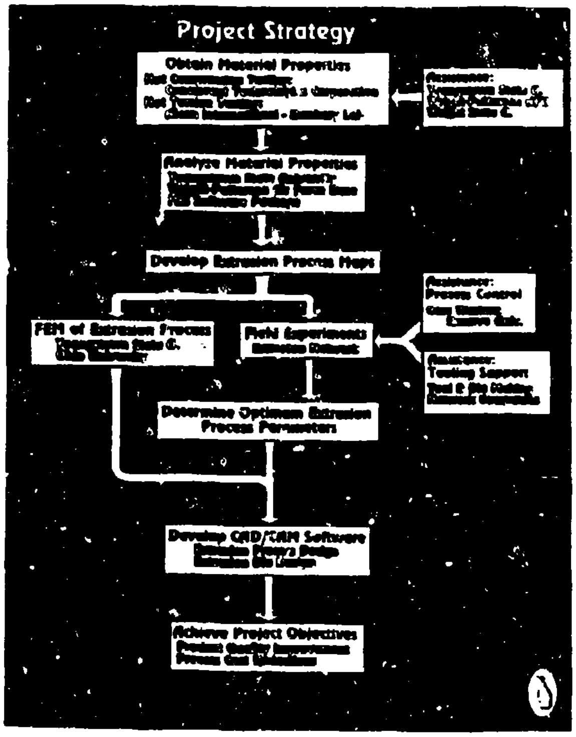





IMPACT OF RESEARCH
PROCESS EFFICIENCY
PROCESS QUALITY
COST


CAD DESIGN PACKAGE
Operational
Tool Integrity
Metal Flow
Press Selection
Number of Holes
Deflection
Dish
Die Pocket Geometry
Bearing Length


Project Introduction
Project 1
Optimal Extrusion Process Design
i) Determine the optimum extrusion process parameters using Dynamic Material Modeling
ii) Develop an automatic feedback control system to regulate the extrusion process
Project 2
Finite Element Modeling
Model the extrusion process to achieve further understanding and improvement of the process
Project 3
CAD/CAM Computer Software
i) Develop an extrusion process simulation package to improve quality and reduce production costs
ii) Develop an extrusion die design software package to replace the "Trial and Error" approach


Project Strategy
Obtain Material Properties
Analyze Material Properties
Develop Extrusion Process Maps
Assistance:
Process Control
FEM of Extrusion Process
Field Experiments
Assistance:
Testing Support
Determine Optimum Extrusion Process Parameters
Develop CAD/CAM Software
Achieve Project Objectives

Conclusion

Significant Contributions and Results:

Academic

1) Multi-University involvement
   - Youngstown State University
   - Ohio University
   - Wright State University
   - Case Western Reserve University
2) Students gain practical experience
3) Faculty gain and contribute knowledge to industry

Industrial

1) Network participants realize gains from a cooperative research effort
2) Benefit from the newest technologies through exposure to Universities and Federal Research Labs
3) Enrichment of the Network's personnel
4) Upgrade the aluminum extrusion and tool & die making process and practice

Economic (local)

1) Enable local companies to become more competitive
2) Improve the participating companies' profits
3) Encourage a cooperative atmosphere between industry and academics
4) Provide a model for similar efforts by other industries

MR. ALLAN FREEDMAN

NORTHROP CORPORATION

PRESENTATION NOT AVAILABLE

MR. BILL HARGROVE

LOCKHEED AERONAUTICAL SYSTEMS CO.

Aerospace Materials and Processes Technology Reinvestment Workshop

May 1993 Dayton Ohio

Lockheed Aeronautical Systems Company

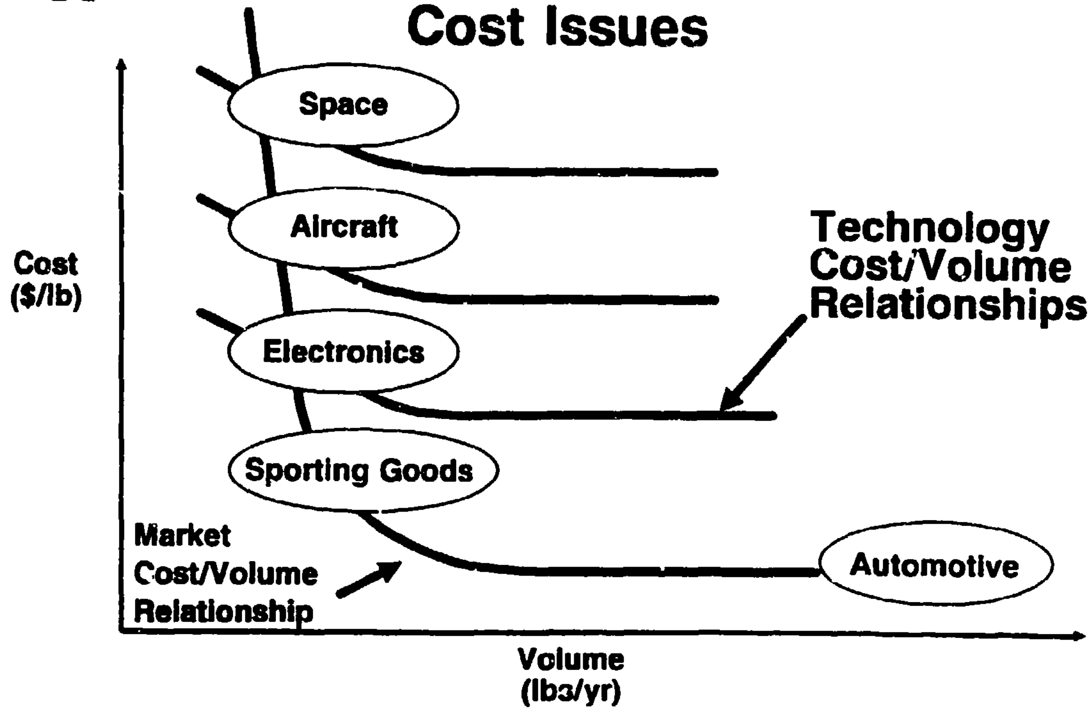
Overview

- Potential Commercialization
- Supplier/Vender Issues
- Lockheed Experience
- Procurement Issues
- Future Programs

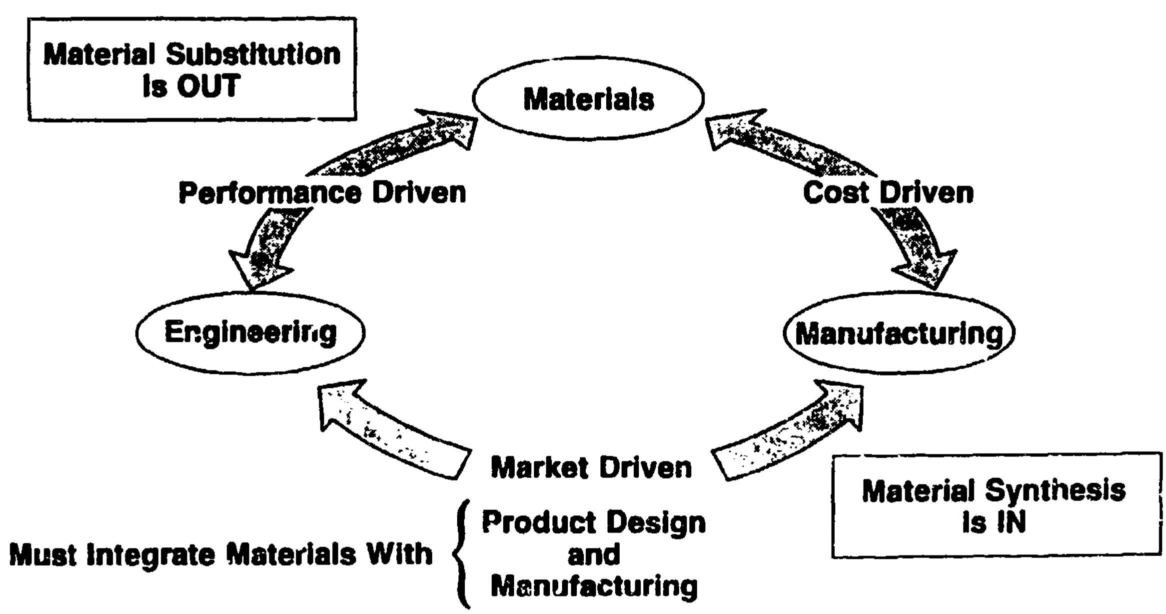
Commercialization of Aerospace Materials

- Commercial Aircraft
  - Metallic Materials Widely Used
  - Composite Materials Widely Used on Secondary Structure
  - Composite Materials Not Widely Used on Primary Structure
- Non Aerospace Products
  - Sporting Goods (Tennis Rackets, Golf Clubs)
  - Industrial Products (Oil Field "Down Hole" Applications)
  - Performance Driven Applications (Automotive)
- Commercialization Issues
  - Cost of Raw Materials and Fabrication
  - Standardization

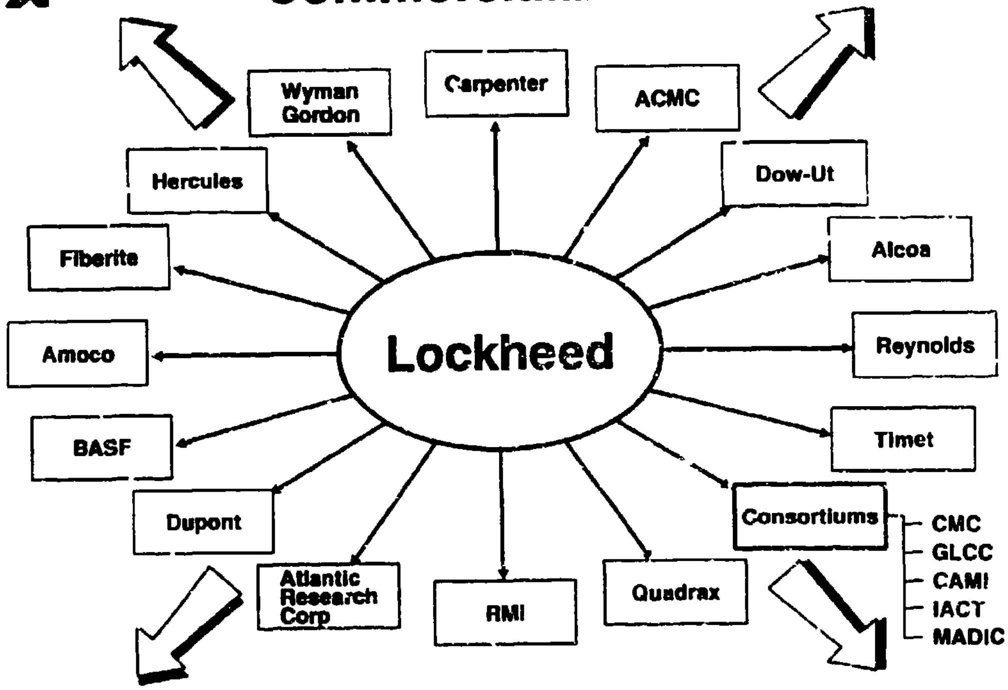
The Polymer Composite Cost Issues



The Standardization Issue



Commercialization



Environmental Health and Safety

- Hazardous Materials (Toluene, Xylene, Isocynates, Methel Ethel Ketone, etc.)
  - DoD Desires Alternative Materials
  - Mil-Spec QPLs DO Not Allow Alternative Materials
- Materials and Process Solutions Required
- Product/Field Implementation
- Recycling and Disposal

Lockheed Experience

Composite Materials Characterization Inc

- 8 Industry Members
- 5 Year Track Record
- 47 Materials in Data Base
- Standardized Test Methods

Aircraft, Helicopter, Missile, and Engine Programs

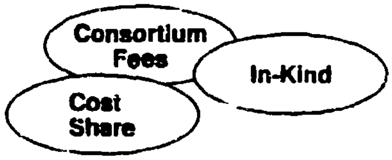
Consortium Objectives:

- Reduce Testing Cost
- Advance State-of-the-Art
- Establish Standards

Procurement Issues

- Defense Acquisition Procurement (FARs and DARs)
- Defense Production Act - Title III
- ManTech and IMIP
- Small Business Innovation Research (SBIR)
- Cooperative Research and Development Agreements (CRADAs)
- Strategic Partnership Initiative (SPI)
- Defense Conversion and Reinvestment

Cost Share Issues



- Product Base Is Declining
- Downsizing of Facilities
- Pressure to Reduce Overhead Costs
- Reducing Research and Development Efforts

Technology Push

- High Speed Civil Transport
- Subsonic Commercial Airlift
- Next Generation Fighter
- VSTOL Fighter
- National Aerospace Plane

Summary

- There are More Co-Operative Ventures
- The Aerospace Materials Industry Is Changing
- Industry Is Moving Toward Lean, Flexible Enterprise
- Cost Sharing Must Make Business Sense
- Good Planning Is Essential

MR. JAMES DORR

MCAIR

PRESENTATION NOT AVAILABLE

MR. BILL YEE

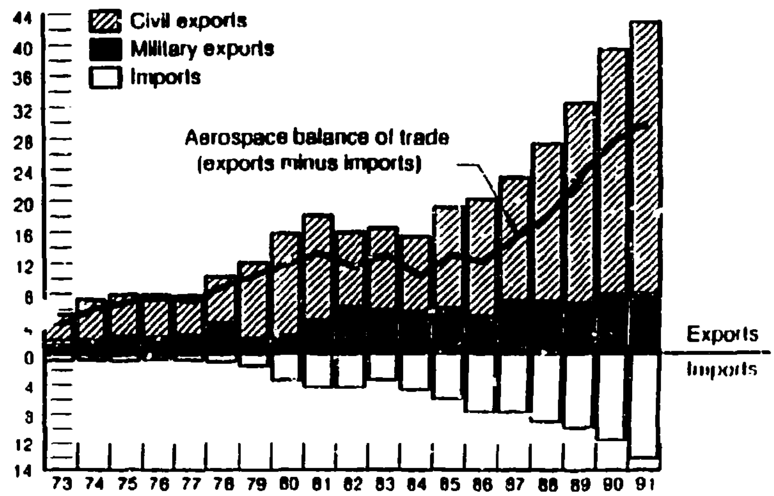
PRATT & WHITNEY

TECHNOLOGY REINVESTMENT

DR. B.G.W. YEE, DIRECTOR
MATERIALS & PROCESS ENGINEERING
18 MAY 1993

AEROSPACE EXPORTS, IMPORTS, AND TRADE BALANCE

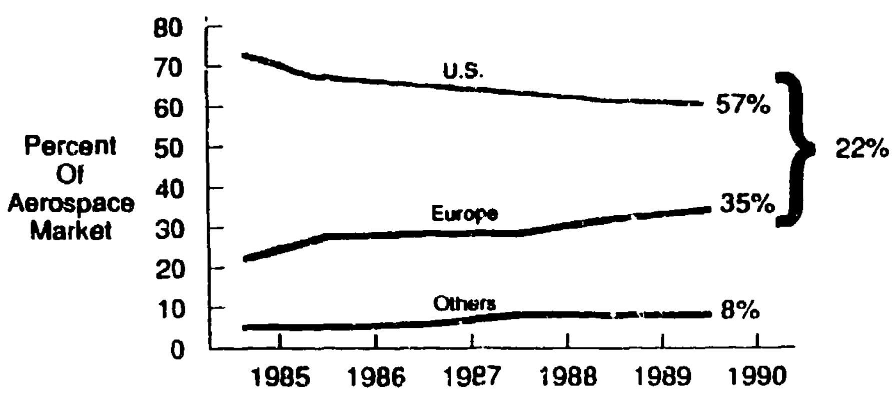
A positive trend



Source: Aerospace Industries Association

THE WORLD-WIDE TRENDS ARE NOT ENCOURAGING

Percent of World Aerospace Market



Source: AEDC Office for International Affairs

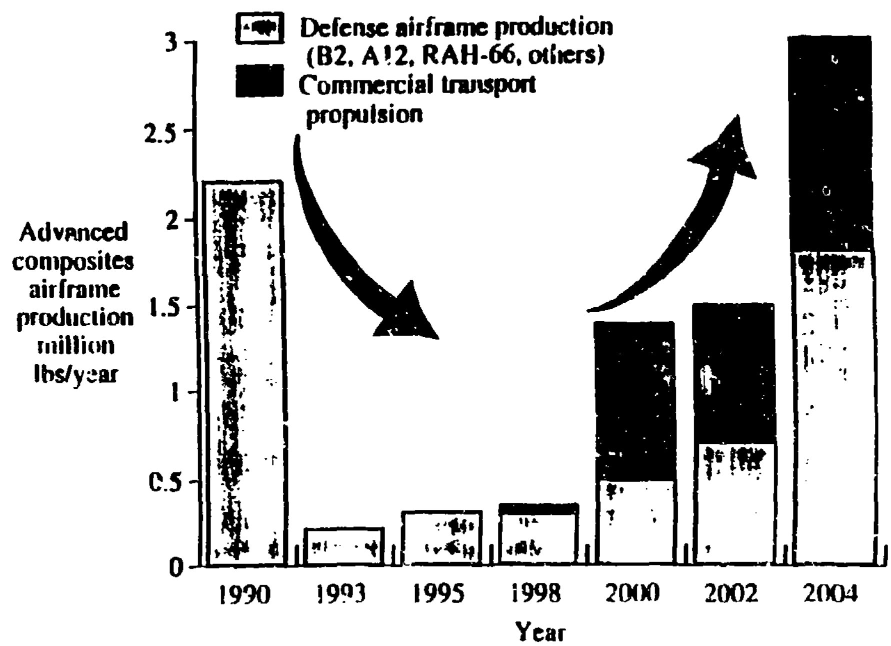
TECHNOLOGY REINVESTMENT

A National Priority

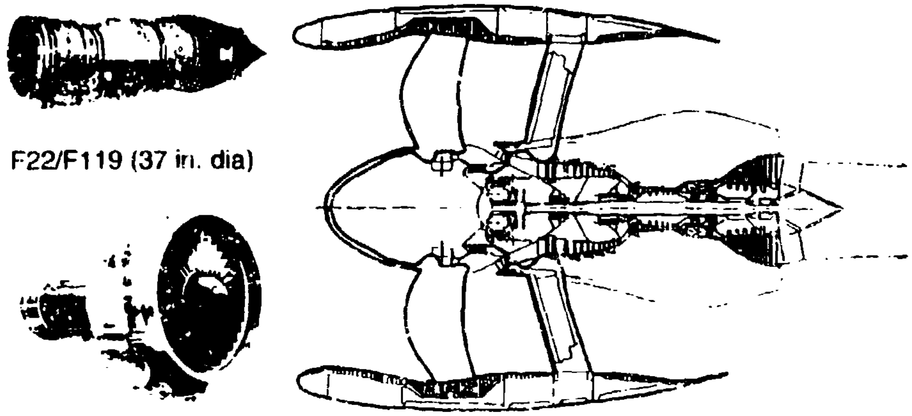
Project Candidate Characteristics

- Maintain U.S. competitiveness in aerospace
- Create U.S. jobs
- Critical defense technologies
- Maintain U.S. industrial base
- Dual-use technologies
- Integrated vertical and horizontal teaming approach

TECHNOLOGY REINVESTMENT BOLSTERS ADVANCED COMPOSITES PRODUCTION BASE



SIZE COMPARISON (Fan Diameter)



F22/F119 (37 in. dia)

C17/F117 (78 in. dia)

100K ADP (160 in. dia)

TECHNOLOGY REINVESTMENT
Summary

- Technology projects should focus primarily on risk reduction of materials/processes technologies (level 6.3 or beyond)
- Composites technology is critical to next generation propulsion systems
- Increase material usage assures U.S. industrial base capability for the future
- Dual usage strategy key for achieving commercially affordable costs
- Technologies at 6.1 and 6.2 level considered too high risk for technology reinvestment (cost sharing)
- Affordability is the key issue

DR. DICK HOPKINS

WESTINGHOUSE SCIENCE & TECHNOLOGY CTR.

Silicon Carbide (SIC) - The Semiconductor With the Right Stuff

Rectification in a Hot, Chemically Active Environment

Silicon Carbide Beats Nearest Competitor

High Power

- 10X Power Density
  - Reduced Parts, Size, Cost
  - New Capabilities: Stealth Detection

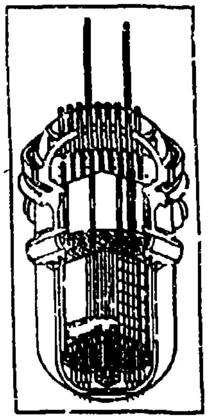
High Temperature

- 650° Operation vs. 150°
  - Less Cooling, Weight, System Cost
  - 1,000X Reliability

Radiation Hard

- 100X Gamma, 50X Neutron Resistance
  - First In-Core Electronics for Protection and Control
  - Reduced Cabling, Penetrations and Cost
  - New Services

Transistors for Long-Range Surveillance



Electronics in Severe Environments · All-Electric Vehicles

In-Core Flux and Temperature Measurements at 100 MRad 350°

SILICON CARBIDE ELECTRONICS HAS BEEN RECOGNIZED AS DUAL USE SINCE THE INCEPTION OF THE WESTINGHOUSE SIC INITIATIVE

SIC is a Superior Semiconductor for:

- **High Temperature**
- **High Power**
- **RAD Hardness**

and Westinghouse Has Internal Uses for Most of the Potential Applications

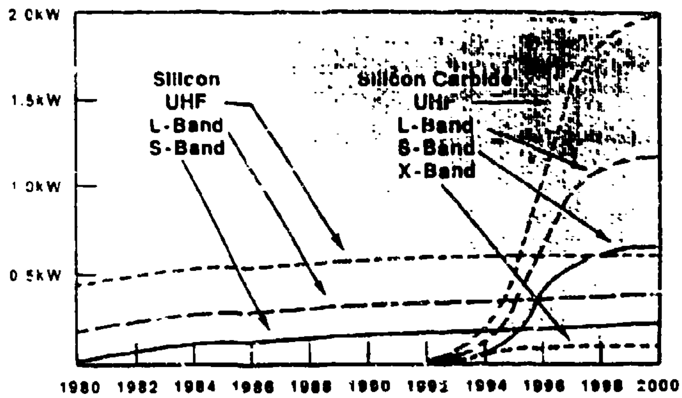
- **DEFENSE SYSTEMS**
  - Radar
  - Communications
  - E-O
  - ECM
  - Signal Processing
  - Aircraft Electrical Systems
  - Nuclear Power
  - Space Sensors
- **COMMERCIAL SYSTEMS**
  - Power Generation & Controls
  - Automotive Electronics
  - Waste Management
  - Non-Volatile Memory
  - Nuclear Instrumentation
  - Electric Vehicle Drives
  - Broadcast Transmitters
  - Microwave Satellite Links

Silicon Carbide : A Breakthrough Technology to Leapfrog the Performance Impass of Current Semiconductors.

We Need:

1.) Over 700 Watts UHF (e.g. AEW,CLO,SPS-40)
2.) Over 250 Watts L-Band (e.g. AEW,CLO,TPS-63,ARSR-4)
3.) Over 150 Watts S-Band (e.g. TPS-75,E-3,SBR,SPY-1)
4.) Over 15 Watts X-Band (e.g. ATF,MODAR,GBR)

Device Peak Output Power



SiC Excels at:
- High Temperatures
- High Power
- High Voltage
- High Radiation

System Benefits:

Higher Device Power
- Less Hardware
- Less Cost

Higher Temperatures
- Improved Cooling

New System Possibilities
- Smaller
- Lighter
- Higher Power

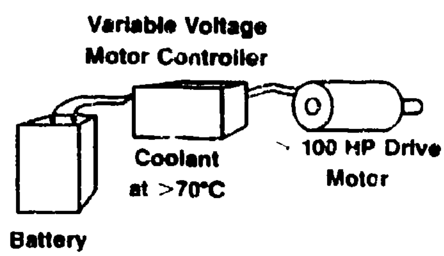
3S482 / VS3236

THE BENEFITS OF SiC VMOS TO COMMERCIAL ELECTRIC VEHICLES . . . .

Higher Temperature Operation
- Air Cooling
- Higher Safety Margin
- Integrated Motor/Electronics

Higher Efficiency
- Lower R_{ON}
- Lower Switching Losses
- Passive Cooling

Lower Cost
- Simpler Cooling
- Higher Power Per Device
- More Rugged Devices



ALSO APPLY TO COMMERCIAL & MILITARY AIRCRAFT
- Current Electronic Thermal Management Adds Significantly to Aircraft Weight
- Emerging Needs: Engine and Skin Mounted Sensors & Control Devices
- Savings: $10,000/lb. for 300 Aircraft Over 15 Year Life

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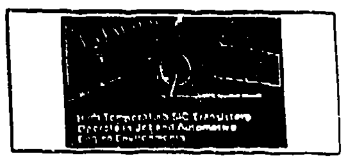

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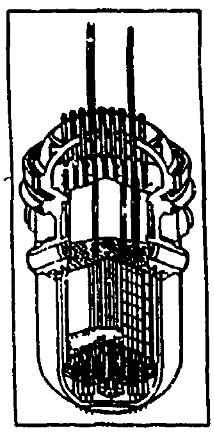

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  - Microwave Satellite Links

STC

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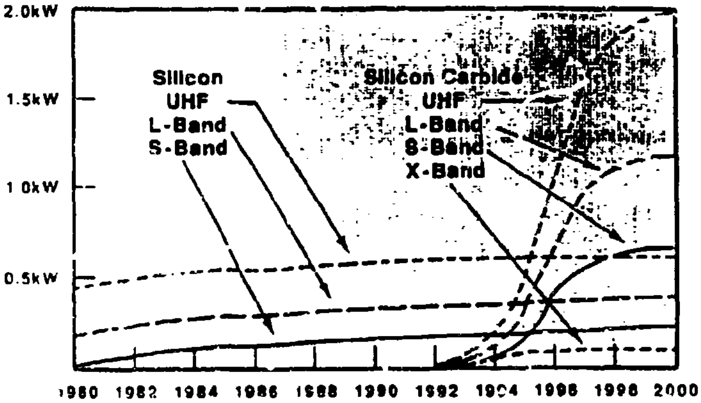

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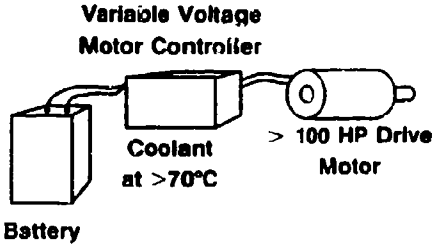

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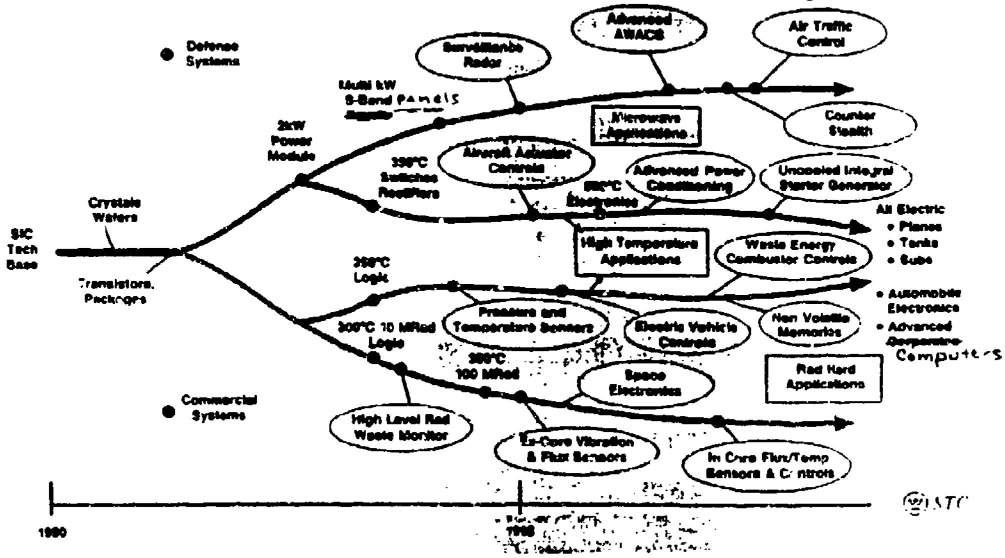
STC

Silicon Carbide Payoff

Versatile Dual Use Technology for a U.S. Competitive Edge



STC

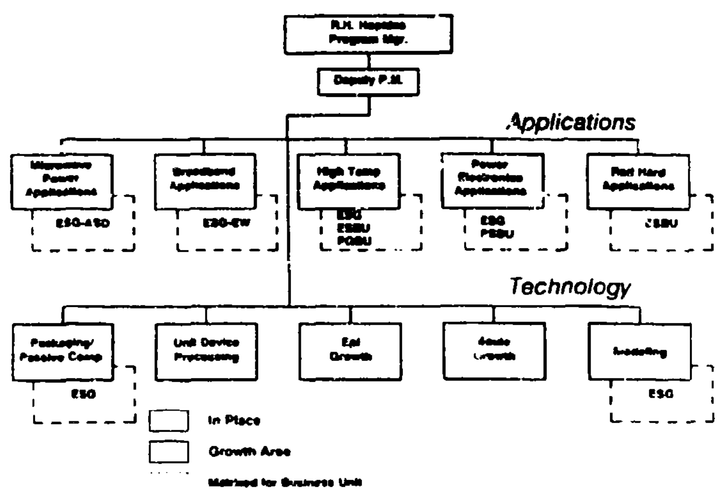
SILICON CARBIDE INITIATIVE

Westinghouse Is Committed to SIC Development and Commercialization

- Product Opportunities Are Broad-Based and Fit Corporate Businesses
- $7M Already Invested in Development
- Program Growing Rapidly
  - Three Engineers in 1989; Over 30 in 1993
- Major New Investments in 1993
  - Capital and Facilities Acquisitions (Furnaces, Epi, Water Prep, Testing)
  - System Engineering/Product Development
  - Expansion of Technology Development Activity
  - Technology and Business Alliances
  - Cost Sharing

We Have Organized to Accelerate Technology Development and Product Transition

THE WESTINGHOUSE SILICON CARBIDE INITIATIVE IS VERTICALLY INTEGRATED FOR RAPID PRODUCT DEVELOPMENT



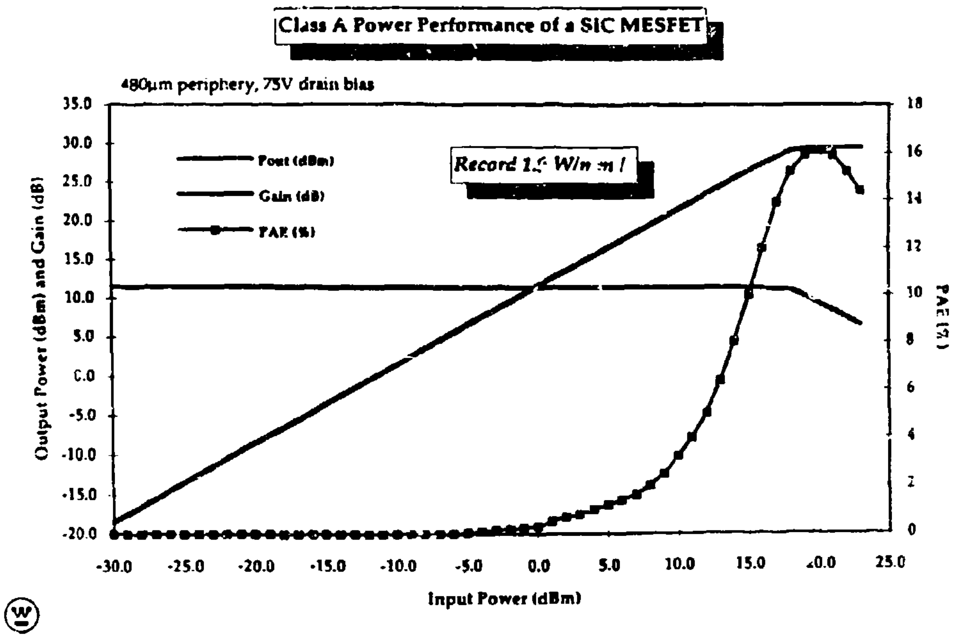
40-mm DIAMETER, HIGH RESISTIVITY 6H-SiC MICROWAVE SUBSTRATE

SILICON CARBIDE ELECTRONICS

Discrete Devices and Basic Circuits are under Development at Westinghouse Now

- **Static Induction Transistor (SIT)**
  - **UHF to S-Band Power Applications**
- **Metal Semiconductor Field Effect Transistors (MESFET)**
  - **X-Band Power and High Temperature Logic**
- **Vertical Metal Oxide Semiconductor Field Effect Transistor (VMOS)**
  - **High Power, High Temperature Switching and Power Conditioning**
- **IMPATT Diode**
  - **High Power Microwave/mm-wave Sources to 35 GHz**
- **Operational Amplifier**
  - **Signal Conditioning and Logic for Hostile Environment Sensors/Controls**
- **Non Volatile Memory**
  - **Ultralong Retention Memory at Room and High Temperature.**

Technology with Total Quality — Westinghouse Science & Technology Center



TEAMING IS AN INTEGRAL PART OF THE WESTINGHOUSE SiC DEVELOPMENT PLAN

Strategic Approach

Use:

- o Corporate Initiatives to Develop Key Technologies (Materials, Device Processes, etc.)
- Business Unit Resources to Carry Out Specific Applications Developments
- Technology Partnerships to Fill Knowledge Gaps, Strengthen Tech. Base
- Business Alliances to Broaden Product Applications
- Customer Contracts to Open New Applications and to Accelerate Technology Development

Then:

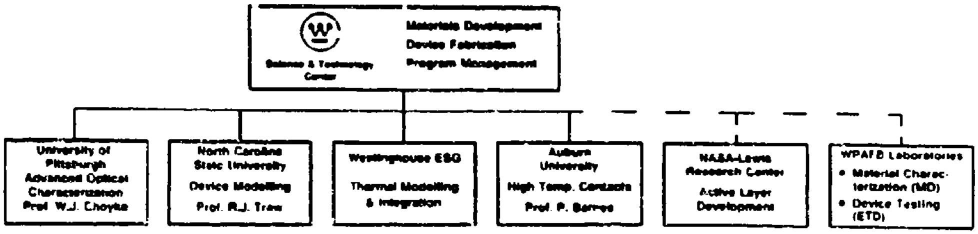
- Business Units Introduce Products in Commercial and DOD Markets

STC

WESTINGHOUSE-AF-NASA-UNIVERSITY TEAMING FOR ADVANCED MATERIALS AND MICROWAVE DEVICE DEVELOPMENT

Goals
- Large Diameter, Low Defect Semi-Insulating Wafers
- 20 W (4X Power Density Increase) X-Band FETs
- 500°C Device Function
  - Key to Advanced Radar and Communications Transmitters

Team Advantage:
- Bring Together More SIC Expertise Than Exists in Any Single Group
- Capitalize on Resources Already Invested in SIC at Organizations Elsewhere
- Promote Technology Synergism and Fresh Ideas
- Foster Broad-Based Industry-University Government SIC Infrastructure



Led To:
- AF - Sponsored Program
  - 40% Cost Shared by Westinghouse
  - Standard FAR Provisions on Intellectual Property
  - Aggressive Jointly Developed Goals

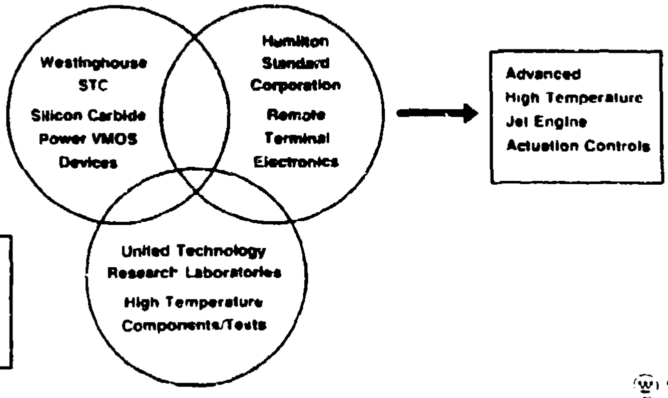
WESTINGHOUSE-AF-NASA-UNIVERSITY TEAMING

Significant Results Have Already Been Achieved

- Record Power Density (1.9 W/mm) FET at 1 GHz Demonstrated
- 2 Inch Diameter SIC Wafers First Step to Scale-Up
- New Low Resistivity Contact Metal Process Will Improve Device Performance
- Model Simulation of MESFETs Leads to Improved Designs
- Identification of Wafer Contaminants by Special Optical Methods Leads to Improved Growth

HAMILTON STANDARD-UTRC-WESTINGHOUSE HIGH TEMPERATURE ENGINE ELECTRONICS TEAMING

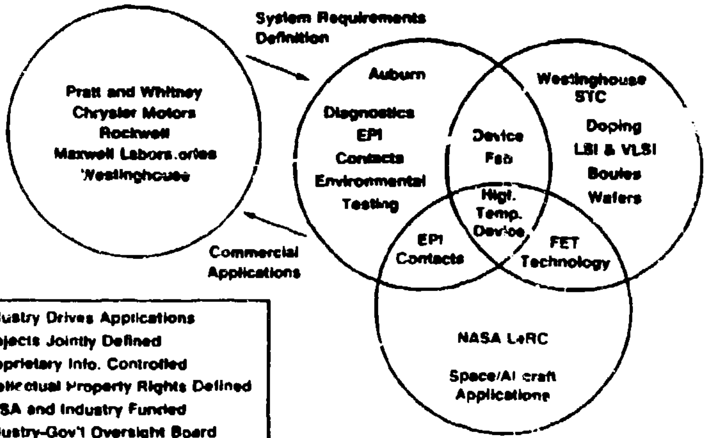
- Grew Out of Joint Interests
  - New Customers for Westinghouse Products
  - Need for High Temperature Engine Electronics
- Led to Air Force Funded Actuator Development



- Air Force Aeropropulsion Division Supported
- Standard FAR Regulations on Property
- AF/Team Defined Program

NASA / AUBURN CENTER FOR COMMERCIAL DEVELOPMENT OF SPACE POWER AND ADVANCED ELECTRONICS

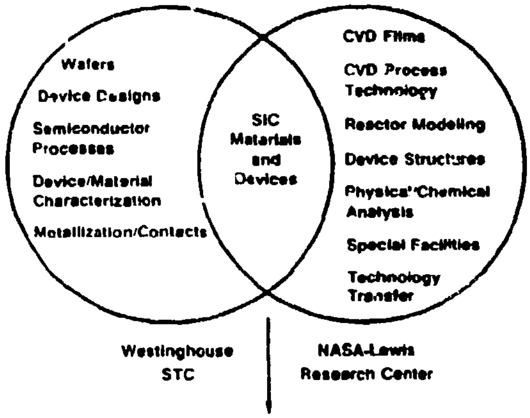
Complementary Skills Linked to Accelerate Silicon Carbide Electronics to Commercialization



- Industry Drives Applications
- Projects Jointly Defined
- Proprietary Info. Controlled
- Intellectual Property Rights Defined
- NASA and Industry Funded
- Industry-Gov't Oversight Board

NASA-WESTINGHOUSE SILICON CARBIDE "SPACE ACT" PARTNERSHIP

The Goal Is to Accelerate the Commercial Development of Silicon Carbide Semiconductor Technology



- CRADA-Like Vehicle
- Each Party Funds Own Effort
- Proprietary Info. Protected
- Joint Task Definition
- Patent Rights Defined

COMMERCIALIZATION

STC

SILICON CARBIDE ELECTRONICS

Off-Shore Silicon Carbide Programs Have Expanded and Our Competitors Are Forming Their Own Teams

Europe

- * Siemens - epitaxy, power devices, blue LED's
- * Daimler Benz - epitaxy, high temperature/high power devices
- ** Thompson CSF - microwave devices
- Merlin Gerin - power devices
- LETI (Grenoble) - epitaxy, device processing, implants
- Asea Brown Boveri - power/high temperature.,
- IBM (Zurich) - epitaxy, blue LED
- * Erlangen U. - boules, epitaxy, physics
- U. Stuttgart - FTIR, ion beam mod.
- * U. Paderborn - defects
- Fraunhofer Inst. - Raman Studies, defects
- CERN - radioactive nuclei.
- U. Amsterdam - defects, spectra

Japan

- Sanyo - boules, blue LED's
- Sharp - blue LED's
- NKK Steel - boules (?
- NEC - boule, devices (?)
- Nissan - high temp. devices
- Sumitomo - materials
- Toyota - MOSFET's
- Electrotechnical Lab - rad. effects
- Kyoto U. - boules, epi, devices

Russia

- Electrotechnical U. - boules thermochemistry
- Ioffe Inst. - modeling, devices, epi
- Kiev Inst. - characterization, epi

*Germany initiated three-year $28M DM SiC Program in 1993

**Thomson has teamed with Daimier

STC

SILICON CARBIDE ELECTRONICS

Government Support for Silicon Carbide has Grown But ....

- Programs Tend to Be Small, Distributed Across Several Agencies
- Lack Critical Mass to Rapidly Advance Technology to Application ($4-5 M/yr)

Navy
- Westinghouse/ATM - IMPATT diodes
- NRL - epitaxy, device fab.
- N.C. State - advanced epitaxy
- Cree - MESFET development
- N.C. State/Cree - device process technology
- U. Pittsburgh - characterization
- Rockwell - Schottky barrier contacts
- ATM - TiC substrates
- INRAD (SBIR) 3C boules

DARPA/ONR
- Cree - blue LED's and lasers

SDIO/ONR
- Cree - NVRAM

NIST
- Cree - boule and epitaxy technology

Air Force
- Westinghouse - boules and X-Band MESFETs
- GE/Cree - high temperature electronics
- GE/Cree - engine "light-off" sensor
- Pratt & Whitney/Westinghouse - high temperature VMOS for actuators
- ATM (SBIR) - improved material
- Cree (SBIR) MESFETs
- Carnegie-Mellon - defects, DLTS
- Oregon Grad. Ctr. - contracts

NASA
- Lewis (in house) - epi. devices
- Kulite (SBIR) - sensors
- Auburn CCDS - implants, epi, contracts, modeling
- Case Western - defects, TEM
- Howard YU. - epitaxy, FET's
- U. Pittsburgh - sensors

SILICON CARBIDE ELECTRONICS

The U.S. Now Leads Silicon Carbide Technology and Product Development ...

— But the Effort is Limited, and Subcritical for Rapid Commercial/DOD Insertions

Industrial	University	Government
Westinghouse	Auburn	NASA Lewis
Cree	Cincinnati	Naval Research Labs
General Electric	Lehigh	Air Force Wright Labs
Advanced Technology Materials	Pittsburgh	Sandia Labs
Texas Instruments ?	North Carolina State	Army Research Labs (Adelphi)
Motorola ?	R.P.I.	
Rockwell ?		
InRad		

And Foreign Competition is Growing

Technology Reinvestment Programs Can Help ....

SILICON CARBIDE ELECTRONICS

'Reinvestment Funds" Offer Significant Potential to Accelerate Technology Development/Deployment ....

- Commercialization, Competitiveness, Defense Industrial Base.

But There's No Free Lunch:

- Shotgun Weddings may lead to Bad Marriages
  - Partnerships need clear goals and good chemistry
  - Most complimentary partners may be competitors.
- Intellectual Property Rights can be a Sticking Point
  - Who owns the future business evolved from "precompetitive" activity?
- There is an inherent Conflict in Defense Conversion Approach
  - Cost sharing necessary but many firms have large restructuring costs
  - Focus tends to near-term problem solving.

Materials Technologies Possibly at Risk during Change in Defense Funding Strategy

- "Upstream" Technology: The Earlier in the Product Development Cycle, the More Difficult to Acquire Development/Cost Share Funds.

Technology with Total Quality — Westinghouse Science & Technology Center

SILICON CARBIDE ELECTRONICS

Summary:

- Silicon Carbide-Based Electronics have Significant, Diverse Commercial and Military Markets.
- Recent Breakthroughs in Materials and Device Process Make Product Exploitation Realizable.
- The U. S. is Now the SIC Leader; (Subsidized) Foreign Competition is Growing.
- The Technology is Immature and the Activity Fragmented Among a Few Companies.
- Agency Support has Grown, But Remains Diversified and Below Critical Mass.
- The Pace of Silicon Carbide Development and Application is Resource Limited.
- The Timing is Right to Invest:
  - Major commercial payoffs are identified
  - Key Technology Issues are known
  - The groundwork has been laid for rapid progress toward products.

Westinghouse Science & Technology Center

NCAT UPDATE

MAY 1993

NATIONAL CENTER FOR ADVANCED TECHNOLOGIES

THE NCAT PROCESS

PLANS ➡ DEMOS ➡ PRODUCTS

WHAT'S NCAT

- A NON-PROFIT EDUCATION AND RESEARCH FOUNDATION
- ESTABLISHED IN 1989 TO PROVIDE A NATIONAL FOCAL POINT FOR COORDINATION OF ADVANCED TECHNOLOGIES BETWEEN INDUSTRY, GOVERNMENT AND ACADEME
- CURRENTLY FUNDED BY AIA, DOD, AND NASA
- ACTIVELY SUPPORTED BY EIA, NSIA, AIAA, ADPA, NAM, SME AND AMT

THE NCAT STRATEGY OF COOPERATIVE CONSENSUS

- INVOLVE INDUSTRY, GOVERNMENT, AND ACADEMIA IN ALL ACTIVITIES
- DEVELOP STRATEGIC PLANS FOR KEY TECHNOLOGIES
- IDENTIFY POLICY AND TECHNOLOGY IMPLEMENTATION ISSUES
- WORK WITH TRADE ASSOCIATIONS AND PROFESSIONAL SOCIETIES (AN ASSOCIATION OF ASSOCIATIONS)
- FOSTER IMPLEMENTATION THROUGH DEMOS
- ADVOCATE RAPID COMMERCIALIZATION

NCAT OBJECTIVES

CONCURRENT ENGINEERING

INTEGRATED PRODUCT/PROCESS DEVELOPMENT

APPLY

COMMERCIAL INDUSTRY

EXPERTISE

TO

TECHNOLOGY

DEVELOPMENT STRATEGY

ADVANCED TECHNOLOGY DEMONSTRATIONS

DEMONSTRATIONS OF ENGINEERING & MANUFACTURING OPERATIONS

2 X PRODUCTIVITY

1/2 X TIME TO APPLICATION

CHANGING ROLES AND ACTIVITIES

NCAT GOAL ➡ **IMPROVING U.S. COMPETITIVENESS** ➡

PAST (89-92)	SHORT TERM (93)	LONG TERM (93-95)
KEY TECHNOLOGIES	**DEMO FORMATION**	**TECHNOLOGY TRANSITION CATALYST**
• GENERATE PLANS • HOLD SYMPOSIA • GIVE BRIEFINGS • SELECT DEMOS	• COMPLETE PLANS • WORK DEMOS (INCLUDING IPPD) • PROVIDE INTERFACE FOR INCREASED GOVT/ INDUSTRY/ACADEMIA COOPERATION • EMPHASIZE AFFORDABILITY	• CONTINUE STRONG TIES WITH TECHNICAL COMMUNITY • STRENGTHEN POLICY FORUM • EXPAND TRADE ASSOCIATION PARTNERSHIPS • FORM PARTNERSHIPS, JOINT VENTURES, CONSORTIA • PROACTIVELY INFLUENCE TECHNOLOGY TRANSITION TO PRODUCTS • STRESS COMMERCIALIZATION

AFFORDABILITY IS KEY TO COMPETITIVENESS

ORGANIZATION	TECHNOLOGY TRANSITION PROCESS				
COMMERCIAL INDUSTRY	AVAILABLE TECHNOLOGY	➡	CORPORATE R&D	➡	COMPETITIVE PRODUCTS
NCAT/ ASSOCIATIONS	PLANS	➡	DEMOS	➡	PRODUCTS
DOD (ALSO NASA, DOE, DOC & DOT)	RESEARCH & TECHNOLOGY	➡	ATDS	➡	SYSTEMS

COOPERATIVE EFFORTS

WHAT IS NCAT DOING?

WORKING DEMOS (DEMONSTRATIONS OF ENGINEERING AND MANUFACTURING OPERATIONS)

<u>ACTIVE</u>

- FBL-PBW
- SMART ENGINES
- ADVANCED COMPUTATIONAL METHODS
- INTERACTIVE EI NET

<u>IDEAS</u>

- ENGINEERED MATERIALS
- IN-SITU REMEDIATION
- ADVANCED SIMULATION
- IMPROVED MAN-MACHINE INTERFACE

TECHNOLOGY FOR AFFORDABILITY

- IPPD - ELECTRONICS
- IPPD - MECHANICAL SYSTEMS
- MULTI-USE MANUFACTURING
- SIMPLIFIED CONTRACTING FOR DEMOs
- EDUCATION AND TRAINING FOR IPPD

WHAT IS NCAT DOING? (CONTINUED)

INDUSTRY VIEW OF SPACE TECHNOLOGIES

- **SPACE FACILITY SURVEY**
- **TECHNOLOGY FUNDING SURVEY**
- **REVIEWED INTEGRATED TECHNOLOGY PLAN**

COMMERCIALIZATION OF REMOTE SENSING

NASA, DoE, DoD, DoC, SDIO

EDUCATIONAL VIDEO SERIES ON IPPD

WITH NTU <u>(NATIONAL TECHNOLOGICAL UNIVERSITY)</u>
AND GIT <u>(GEORGIA INSTITUTE OF TECHNOLOGY)</u>

EXPANDING SCOPE OF COOPERATIVE ACTIVITIES

ONGOING

INDUSTRY	-	WORKING DEMOS
DOD	-	TECHNOLOGY FOR AFFORDABILITY (INCLUDES AIA, EIA, NSIA, NAM, AND ADPA)
NASA	-	INDUSTRY VIEW OF SPACE TECHNOLOGIES

NEAR TERM

- DOE, NASA, DOC, AF, SDIO - REMOTE SENSING
- NTU AND GIT - EDUCATIONAL VIDEO SERIES (JULY-DECEMBER '93)

FAR TERM

- DOD, DOE, DOC, DOT, NASA - AFFORDABLE TECHNOLOGY TRANSITION
- OSTP - COLLECTIVE INDUSTRY VIEW OF INITIATIVES

IMPROVING U.S. COMPETITIVENESS

President's Technology Initiative	NCAT Activities
■ *Investing in Technology for Economic Growth*	*Improving Efficiency of Technology Transition (2xproductivity, 1/2xtime to application)*
-- Applied R&D • Manufacturing • Aerospace • Biotechnology • Advanced Materials	-- Key/Critical Technologies -- DEMOs • Smart Engines • FBL-PBW • Adv. Comp. Methods • Interactive EI Net
-- Increased Government/Industry Partnerships	
-- Information Infrastructure	
-- *Technology to cut costs and improve efficiency*	-- *Technology for Affordability* • IPPD • Dual-Use Manufacturing • Simplified R&D Contracting
-- *Educational Technology*	-- *Educational Video Series*
■ *Provide Policy Leadership*	■ *Aerospace Technology Policy Forum*

AIA/NCAT MATERIALS ACTIVITY

1987 CMC FORMATION

1989 ADVANCED COMPOSITES ROADMAP

1990 ADVANCED COMPOSITES CONFERENCE

1991 NATIONAL ADVANCED COMPOSITES STRATEGIC PLAN

1992 DEMO WORKSHOP

PRECISION CASTING MEETINGS

SACMA/USACA/AIA WHITE PAPER

COMPOSITES ISSUES MEETING

1993 COMPOSITE STANDARDIZATION

ADVANCED METALLIC STRUCTURES PLAN

SUMMARY COMMENTS

- COMPANIES CAN COOPERATE EFFECTIVELY ON TECHNOLOGIES
- GOVERNMENT AND INDUSTRY NEED TO DO MORE COOPERATIVE PLANNING
- WE NEED TO APPLY COMMERCIAL EXPERTISE TO TECHNOLOGY DEVELOPMENT STRATEGY
- EFFECTIVE USE OF TECHNOLOGY IS KEY TO COMPETITIVENESS

COOPERATION!
TRY IT! YOU'LL LIKE IT!

MR. NED MAURER

QUESTECH RESEARCH DIVISION

WRIGHT LABORATORY MATERIALS DIRECTORATE

AEROSPACE MATERIALS AND PROCESSES TECHNOLOGY
REINVESTMENT WORKSHOP

ELECTRONIC INDUSTRY PERSPECTIVE

NED A. MAURER
QuesTech, Inc.
(513) 258-2311

OUTLINE

- Electronic Industry Statistics
- Government Responsibilities
- Industry Responsibilities
- Suggested Government Actions
- Suggested Industry Actions
- Proposal: Enhance the SEMATECH Success Story
- Summary

ELECTRONIC INDUSTRY STATISTICS

- Leading Edge Technologies Often Occur in the Civilian Sector and Only Much Later Will Move into Defense.
- Product Life Cycle for Many Electronic Components Is Less than One Year.
- U.S. Electronic Components Industry Markets are:

  Weak: Actuators, Optoelectronics, & Hardcopy Technology

  Losing: Memory Chips, Packaging, & Displays

OTHER FACTORS:

- Over 50% of Doctoral Degrees in Engineering and 40% in Math and Physics are Awarded to Foreign Students.
- Almost 1/2 the US patents Went to Foreign Companies in 1990.

  The top 4: Hitachi, Toshiba, Canon, and Mitsubishi.
- US Investments (1991) in Plant & Equipment Reached a 14 Year Low.

  US 10.7%GDP, Germany 14.5%, Japan 22%

GOVERNMENT RESPONSIBILITIES

ENCOURAGE AND SUPPORT:

- Industry Led Consortia
- Precompetitive Technology Development
- Dual-Use Technologies
- Rapid Implementation of Technological Advances

INDUSTRY RESPONSIBILITIES

ALL US FIRMS SHOULD:

- Create Better Relationships with Suppliers and Customers.
- Increase Employee Involvement and Participation.
- Increase Investments in :
    1. Process Development on a Continual Basis.
    2. Plant & Equipment to Support Agile Mfg. Concepts.
    3. Worker Training on a Continual Basis.
- Goal is to Shorten Cycle Time Required to Bring Products and Processes to Market.

SUGGESTED GOVERNMENT ACTIONS

- **Revise DOD Procurement Regulations to Emulate Private Sector Practices Wherever Possible.**

GOVERNMENT MUST DO THEIR LIMITED PART:

- "Benchmark" What Foreign Government Actions and Align US Programs Against these Benchmarks.
- Establish an Advanced National Technical/Business Communications Network.
- Set the Correct Policy/Procedures to Create Many More Market Driven Extension Centers.
- Redirect the Federal R&D Budget from 60/40 to 50/50 Defense/Nondefense.

MILITARY LAB'S SHOULD BE A FACILITATOR.

- **Provide Technical Expertise, Equipment, & Facilities in a Proper Consortia Mix**
    - Keep Control in Private Sector

SUGGESTED INDUSTRY ACTIONS

- Encourage Real Employee Involvement and Good Labor Management Relationships
- Shift from Mass Production to "Agile" Manufacturing
- Push for Cooperative R&D Agreements with Government Labs and Other Companies.
    1. Share Risks
    2. Pool Resources
    3. Eliminate Duplication of Effort
    4. Make Synergistic Investments
    5. Invest in Private Sector led Consortia like SEMATECH, MCC, NCMS, and Advanced Battery
- Learn All You Can About Your Present and Developing Markets
- Think Global
- Set Your Process Goals to the Highest Practical Standards
- Find Trusting Consortia Partners to Share Your Future

PROPOSAL: ENHANCE THE SEMATECH SUCCESS STORY

- **Military Field Activities: Labs, Centers of Excellence, Logistic Centers**
  - •• Understand that Cooperative Coexistence will Support Your Survival
  - •• Be Prepared to Absorb Downsizing and Market Adjustments. Survival Will Probably be of the Fittest Consortium.

- **Private Industry:**
  - •• Keeping "Key" Processes Locked Up Will Do No Good if There is No Business

- **Government and Industry Should Develop Team Consortia**
  - •• Prepackage Teams to Meet Certain Goals
  - •• Focus Goals on National Needs – Both Economic and Military
  - •• Work With the Public, Congress, and Others to Secure Long Term Cash Flow that Supports the Goals

- **Focus on Process Technologies**

SUMMARY

NEW GOVERNMENT AND INDUSTRY RELATIONSHIPS

- **A New Government/Industry Relationship is Required to Meet the Challenge of the Future.**
  - •• Revolutionary Changes in Process Technology Must be Jointly Developed
  - •• New Training Techniques Must be Discovered and Implemented.
  - •• These are Dynamic and Continuous Processes and Provisions Must be Made in Policy and Procedure to Continually Improve.
- **Key Issue:**
  - •• Government Must First Become a Partner; Then a Customer. The Government Purchasing Power will Help Ensure Domestic Sales for what is Jointly Developed and Provide an Easier Entry into World Markets.
- **Focus Must be on Process Technology.**
- **Ultimate Goal:**
  - •• To Develop New Process Technologies Ahead of World Competition and BEAT the World with Rapid Implementation.
  - •• All Must learn Cooperatively to "Use It" or Individually "Lose It"

CAPT. RICHARD BYNSVOLD

NATIONAL AUTOMOTIVE CENTER
US ARMY

PRESENTATION NOT AVAILABLE

ILIP ENVIRONMENTAL THRUSTS

- FOUR MAJOR USAF ACTIVITIES
  - RISK ANALYSIS
  - CLEANUP, SITE RESTORATION
  - COMPLIANCE, EXISTING TECHNOLOGY
  - $\boxed{\text{- PREVENTION, FUTURE TECHNOLOGY}}$

11

6 Aug 92

POLLUTION PREVENTION R&D

APPROACH

- ELIMINATE THE SOURCES (i.e., EMPTY THE PIPELINE)
- QUANTUM IMPROVEMENTS (LEAP FROG TECHNOLOGY)
- WORK THE DIFFICULT, LONGER TERM, HIGH PAYOFF OPPORTUNITIES

POLLUTION PREVENTION R&D

WRIGHT LABORATORY AREAS OF FOCUS

- o WATER WASTE STREAM ELIMINATION
- o VOLATILE ORGANIC COMPOUNDS (VOCS) ELIMINATION
- o SOLID WASTE STREAM ELIMINATION
- o OZONE LAYER DEPLETING SUBSTANCES (OLDS) ELIMINATION

WL POLLUTION PREVENTION R&D

6Aug92

o WATER WASTE STREAM ELIMINATION

- NON CHEMICAL BASE SURFACE TREATMENTS FOR Al, Ti & Cu ALLOYS FOR BONDING & COATING

  FORMATION OF THERMODYNAMICALLY STABLE SURFACE MORPHOLOGIES

  THIN FILM DEPOSITION, SOL GEL TECHNIQUES HIGH VELOCITY OXYGEN FUEL, FLAME/PLASMA SPRAY LASER BASE PROCESSES

- ADVANCED PAINT STRIPPING TECHNOLOGY

  ROBOTICALLY CONTROLLED PROCESSES PLASTIC MEDIA, WATER, CO2

WRIGHT LABORATORY

POLLUTION PREVENTION PROGRAMS

MATERIALS DIRECTORATE (ML)

ADVANCED METAL SURFACE TREATMENT PROCESSES

OBJECTIVE: TO REPLACE EXISTING WET CHEMISTRY PROCESSES FOR PREPAINT / PREBOND SURFACE PREPARATION OF ALUMINUM & COPPER ALLOYS

APPROACH: R&D INVESTIGATIONS INTO:
- THIN FILM DEPOSITION TECHNOLOGY
- THERMAL SPRAY TECHNOLOGY
- SOL-GEL OXIDE FILM DEPOSITION
- ION-BEAM ENHANCED FILM DEPOSITION

PAYOFF:
- ELIMINATES LARGE WATER CONTAMINATING/USING PROCESSES
- ELIMINATES USAGE OF STRONG ACIDS AND BASES
- ELIMINATES USAGE OF SOLUBLE CHROME

WL POLLUTION PREVENTION R&D

ADDITIONAL STUDY AREAS

- o ADVANCED PRINTED CIRCUIT BOARD PROCESSES
- o ELIMINATION OF WATER BASE METAL DEPOSITION & REMOVAL PROCESSES
- o TURBINE ENGINE OIL RECYCLING
- o SOLID STATE METAL CLEANING PROCESSES
- o ENVIRONMENTALLY ACCEPTABLE "CHAFF" MATERIALS
- o ENVIRONMENTALLY ACCEPTABLE BATTERIES (NiMH)

TWO MECHANISMS FOR COOPERATIVE R&D BETWEEN INDUSTRY & DOD (AIR FORCE)

o DUAL USE TECHNOLOGY DEVELOPMENT PROJECTS (DARPA)

o COOPERATIVE RESEARCH & DEVELOPMENT AGREEMENT (CRDA)

- POTENTIAL AREAS OF INTEREST

  ADVANCED COATING & REMOVAL TECHNOLOGY
  REMOVAL HIGH PERFORMANCE COATINGS
  NON CHROME CORROSION INHIBITING SYSTEMS (NON-LEAD, CADMIUM TOO)
  ADVANCED CONVERSION COATINGS
  ADVANCED FIRE EXTINGUISHING/EXPLOSION SUPPRESSION

Aerospace Materials and Processes
Technology Reinvestment Workshop

MLL Division Overview

METALS and CERAMICS DIV
MLL
Dr Norman M Tallan

Materials Development Br
MLLM
Dr Walter Reimann

- Light Weight Metals
- High Temperature Metals and Intermetallics
- Metal Matrix Composites
- Ceramicr and Ceramic Matrix Composites

Materials Behavior Br
MLLN
Mr Allan Gunderson

- Behavior & Life Prediction of Metals and MMCs
- Behavior & Life Prediction of Ceramic Composites
- Process Modeling
- Process Science Methodology

Nondestructive Evaluation Br
MLLP
Mr Tobey Cordell

- Aging Systems NDE
- NDE Reliability Improvement
- Large Area Composite NDE
- Advanced Materia's & Processes NDE

Aerospace Materials and Processes
Technology Reinvestment Workshop

Topics For Technology Transfer

1. Metals, Intermetallics and MMCs
   - Aluminum Metal Matrix Composites
   - Titanium Metal Matrix Composites
   - Gamma Titanium Aluminides
2. Structural Ceramics

Aerospace Materials and Processes
Technology Reinvestment Workshop

Topics For Technology Transfer (Cont)

3. Metal and Ceramic Material Processing
   - Controlled Dwell Extrusion
   - Controlled Dwell Forging
   - Consolidation Modeling - MMC and CMC
   - Material Behavior Modeling
     - Processing Maps
     - Constitutive Equations
   - Analytical Modeling
     - Deformation
     - Solidification
     - Densification
     - Fluid Flow

Aerospace Materials and Processes
Technology Reinvestment Workshop

Topics For Technology Transfer (Cont)

4. Nondestructive Evaluation
   - Computed Tomography
   - Large Area Composite Inspection
   - High Resolution Radioscopy

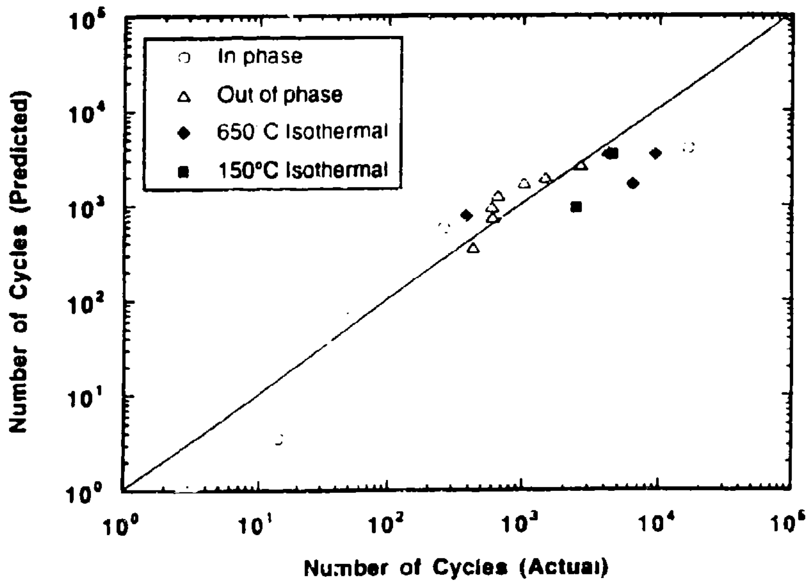
5. Behavior / Life Prediction
   - Titanium, Aluminide and Ceramic Matrix Composites
   - Gamma Titanium Aluminide
   - NASP Specific Materials
   - IHPTET Specific Materials

Life-Prediction Methodologies

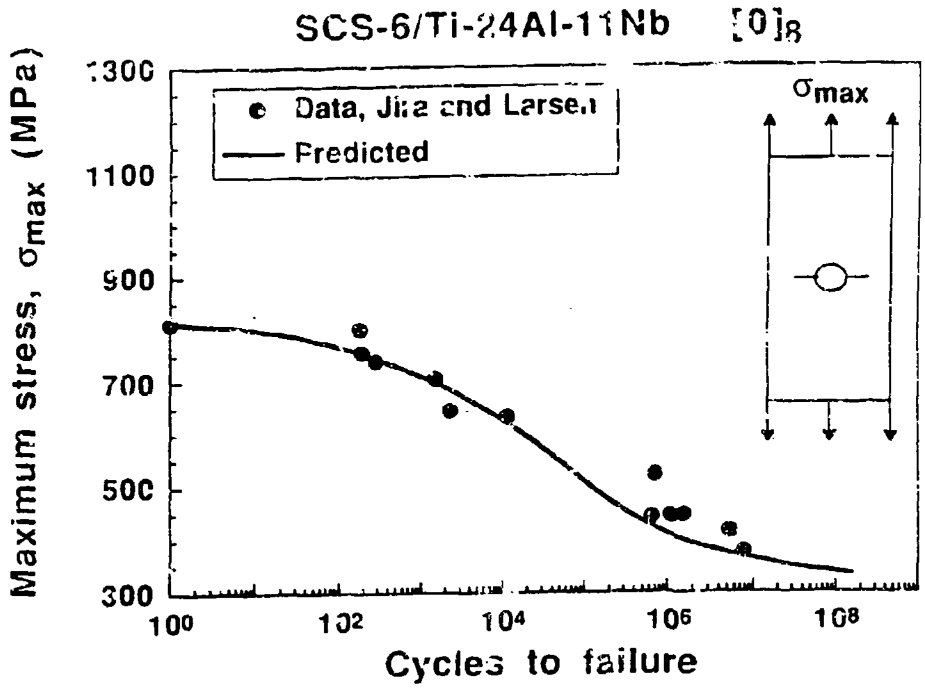
- **Metal Matrix Composites (SCS-6/Ti-24Al-11Nb, SCS-6/Timetal®21S)**
  - Developed models for thermomechanical fatigue damage
  - Developed models for crack propagation from holes and notches
- **Monolithic Metals**
  - Developed methodology to predict crack growth in nickel, titanium, and titanium-aluminide alloys under isothermal and thermomechanical fatigue
  - Developed understanding of crack growth behavior of small cracks
- **Ceramic Matrix Composites (C/SiC, SiC/SiC, SiC/1723, SiC/BMAS, SiC/CAS)**
  - Developed microscope system to study crack formation under fatigue
  - Identified fatigue limits for various systems

Comparison of Predicted and Actual Results for Thermomechanical Fatigue

SCS-6/Timetal®21S [0/90]2S



Prediction of S-N Curve for Specimen With Center Hole



Experimental Mechanics Test Methodologies

- Approach to Experimental Mechanics Testing: Two Basic Activities
  - Imposing conditions on specimen
  - Measuring specimen response
- Imposed Test Conditions
  - Mechanical: force, strain, or displacement
  - Temperature
  - Environment: lab air, vacuum, or inert gas
  - Simultaneous application of all three conditions
- Material Response
  - Mechanical: force, strain, or displacement
  - Electrical properties
  - Geometric changes: self-similar crack growth or multiple cracking

Source: G.A. Hartman, "Integrating Experimental Mechanics Methodologies", ASTM E08.03 Subcommittee Kick-off Lecture 1993

Inert Environment Thermomechanical Fatigue System

- Developed to Enforce Conditions:
  - Uniaxial force or strain as a function of time
  - Uniform temperature distribution as a function of time
  - Inert gas or vacuum environment as a function of time
  - Possible cryogenic testing
- The Specimen Responses That Can Be Measured:
  - Uniaxial force or strain
  - Crosshead displacement
  - Electrical resistance
  - Internal generation of acoustic waves
  - Response to externally imposed acoustic waves

Source: G.A. Hartman, "Integrating Experimental Mechanics Methodologies", ASTM E08.03 Subcommittee Kick-off Lecture 1993

Small-Scale Displacement Laser Interferometer System

- Developed to Meet the Need for Precise Measurement of Specimen Displacements During Mechanical Tests
  - Operates at gage lengths from less than 25µm to over 500µm
    - far shorter than practical with mechanical systems or other optical systems
  - Displacement resolutions of 2nm (20Å) or less can be achieved
  - System is fully integrated with automated test control microcomputers and sophisticated test control software
- Has Been Used to Study Various Small-Scale Phenomena
  - Near-crack-tip displacement fields
  - Strains within a metal grain
  - Strains or displacements inside notches and holes

Source: G. A. Hartman, "Displacement Measurements Using a Short Gage Length Laser Interferometer" ASTM E08 task group presentation, Miami, Florida, November, 1992.

Aerospace Materials and Processes Technology Reinvestment Workshop

Key Personnel

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Metals, Intermetallics and MMCs

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Metals and Ceramics Division

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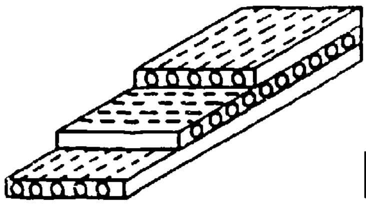
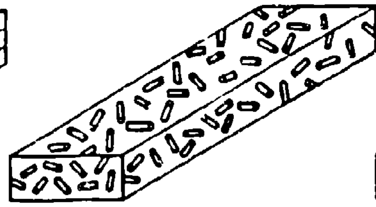
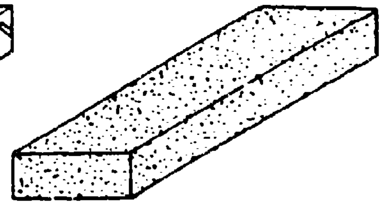
TYPES OF METALLIC MATRIX COMPOSITE MATERIALS



FIBERS



WHISKERS



PARTICULATES

Aerospace Materials and Processes
Technology Reinvestment Workshop

Aluminum Metal-Matrix Composites

- Why are aluminum-metal matrix composites ready for transition?
  - Standardized Products Available for SiC Particulate Reinforced Aluminum Composites
    - Title III Program
    - Manufacturers
      - DWA, Chatsworth, California
      - ACMC, Greer, South Carolina
    - Products
      - Extrusions, Sheet, Plate
  - Production Experience for Fiber Mat Preforms
    - Small and Large Diesel Engine Pistons
    - Squeeze Cast to Infiltrate Preform
- What are their unique features?

Particulate:
- High modulus (stiffness)
- Low coefficient of thermal expansion
- High specific strength
- Wear resistant

Preform:
- Increased use temperature

- Current/Future Uses
  - Department of Defense
  - Non-Department of Defense

Varies as a function of reinforcement type

Aerospace Materials and Processes
Technology Reinvestment Workshop

Aluminum Metal-Matrix Composites

	Continuous Fibers	Fiber Preforms	Whiskers	Particulate
Manufacturing Technologies	Pultrusion Diffusion Bonding Cast	Squeeze Cast	Cast	Cast
Reinforcement	Gr, SiC, Al_2O_3	Al_2O_3	SiC	SiC
Production Components		Diesel		Electronic Rack
Standard Products				Plate Sheet Extrusion

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Technology Reinvestment Workshop

Titanium Metal Matrix Composites

- Why are titanium-metal matrix composites ready for transition?
  - Understanding of the metallurgical and mechanical behavior of several continuous-fiber reinforced TMC systems has been established
  - Widespread use of these materials is needed to solidify and further develop vendor base
  - Fracture-mechanics based life prediction methodologies are being developed for critical aircraft components
- What are their unique features?
  - High specific strength and stiffness
  - Higher temperature use than monolithic titanium without superalloy weight
- Current/Future Uses
  - Department of Defense
    - Airframe components for advanced hypersonic aircraft
    - Support structures (links, struts, strods, exhaust nozzle liners) for near-term turbine engines
    - Bladed rings for advanced turbine engine compression systems
  - Non-Department of Defense
    - Critical and support structures in gas turbine engines
    - Other?

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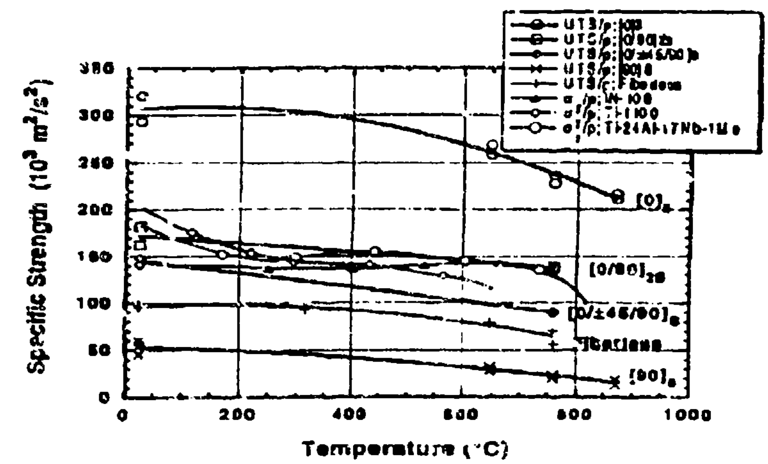
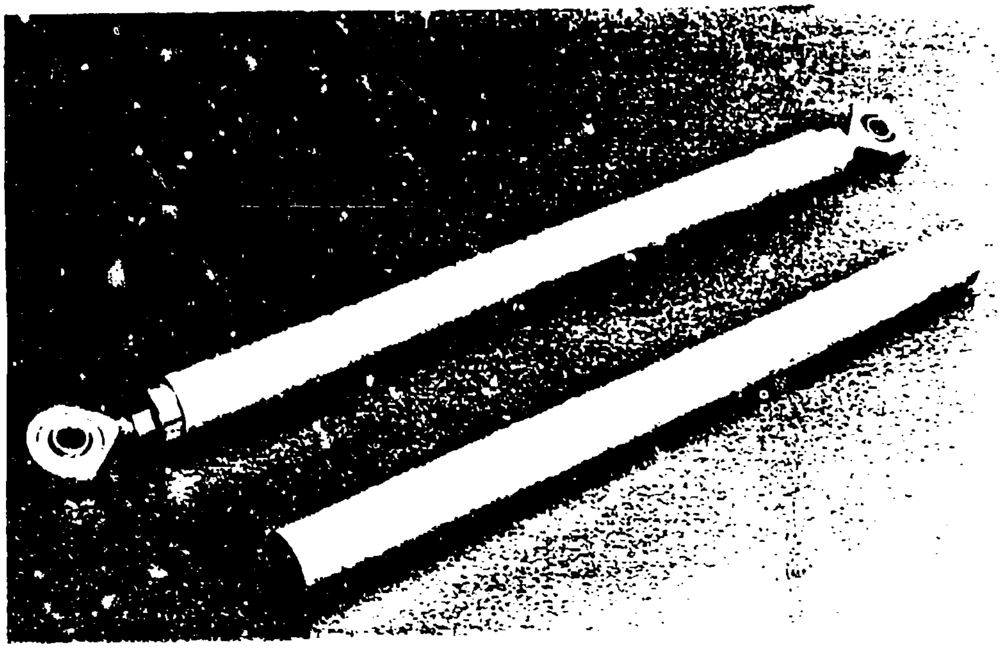
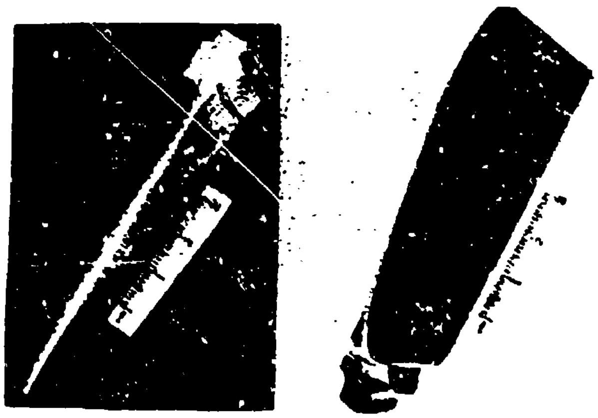
Technology Reinvestment Workshop

Titanium Metal Matrix Composites

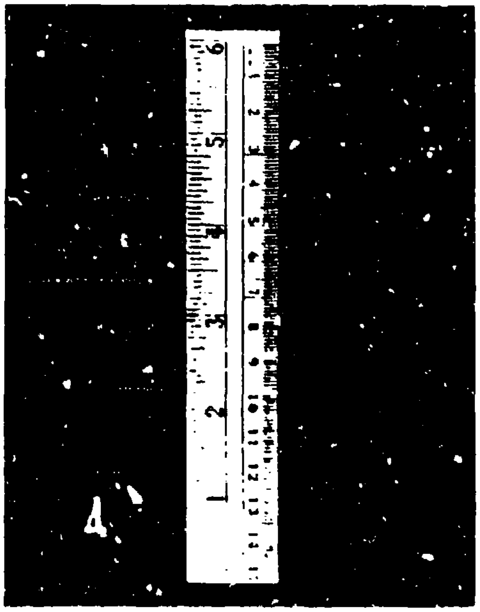


SPECIFIC STRENGTH OF SiC/Ti-24Al-11Nb LAMINATES COMPARED WITH ALTERNATIVE MONOLITHIC MATERIALS
(Reference: Larsen, Revelos, Gambone, MRS, 1992)





Gamma Compressor Blade



Gamma Exhaust Valve

Aerospace Materials and Processes Technology Reinvestment Workshop

Gamma Titanium Aluminides

- Why is gamma ready for transition?
  - Need lighter weight / high temperature material to replace steel and superalloys
  - Knowledge of reproducible microstructure and properties, but technology has reached critical juncture
  - Cast technology is transitioned to vendor base
- What are its unique features?
  - Lighter weight than superalloys and titanium
  - Better high temperature properties (strength, modulus) than superalloys
  - Better oxidation and burn resistance than titanium
- Current/Future Uses
  - Department of Defense
    - Gas Turbine Engines
      - Near Term: Combustion swirler, high-pressure compressor stators, blade outer air seals, nozzle liner tiles
      - Mid Term: Compressor and turbine cases, compressor blades
  - Non-Department of Defense
    - Near Term: Cast automotive exhaust valves
    - Mid Term: Wrought gamma valves, impellers, turbochargers, commercial land-based turbine components, commercial aircraft turbine engine components, and others.

Aerospace Materials and Processes Technology Reinvestment Workshop

Key Personnel

Key Metals, Intermetallics and MMC Personnel:

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Mr Gerald Petrak - Light Weight Metals
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Mr Paul Smith - Orthorhombic Titanium Aluminides
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ASM INTERNATIONAL

WRIGHT LABORATORY

SAMPE

Structural Ceramics

Dr. Allan Katz
Metals and Ceramics Division

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45433-7817

Aerospace Materials and Processes Technology Reinvestment Workshop

Structural Ceramics

Why Ready?

- State-of-the-art Structural Ceramics Have Matured to the Point of Real Application Insertion

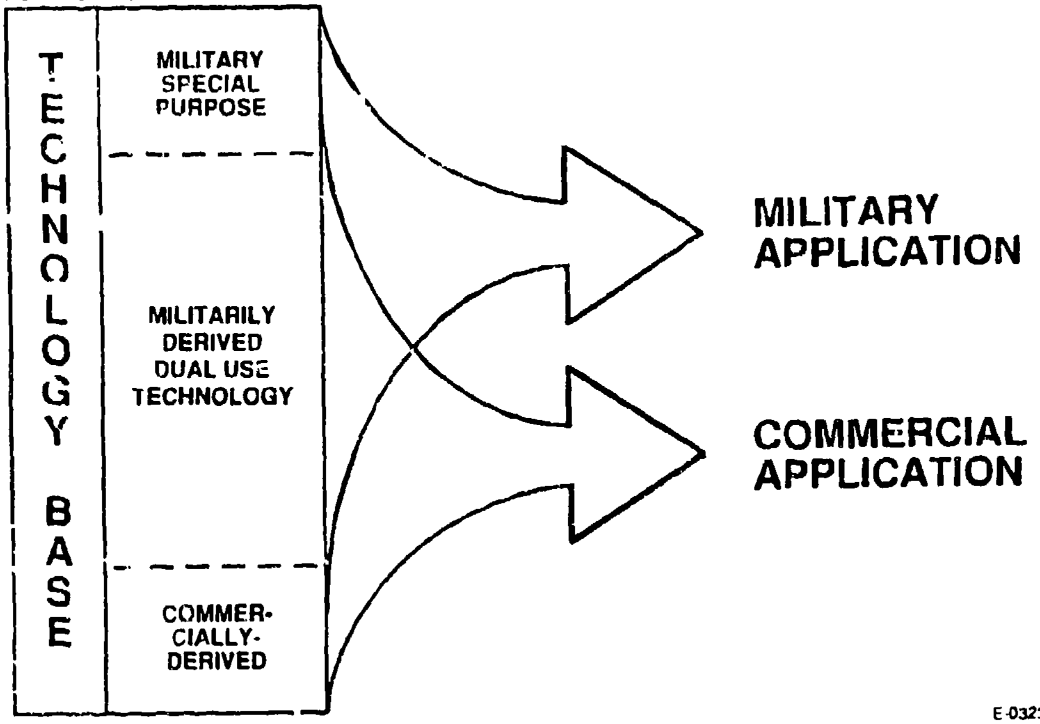
Unique Features:

- High Strength, Stiffness
- Low Density
- Operating Capability to >2000°F
- Low Thermal Expansion Coefficient
- Thermal Shock Resistance
- Corrosion, Oxidation Resistance
- Erosion, Wear Resistance
- Tailorable Electrical Properties
- Non-strategic Constituent Materials
- Amenable to Fabrication by a Variety of Manufacturing Methods
- Resistance to Catastrophic Failure (Toughened Ceramics)

DOD Uses:

- Gas Turbine Engines
  - Aeropropulsion
  - Auxiliary Power Units
- Reciprocating Engines
  - Automotives (Diesel)

IHPTET FEEDS BOTH MILITARY AND COMMERCIAL ENGINES



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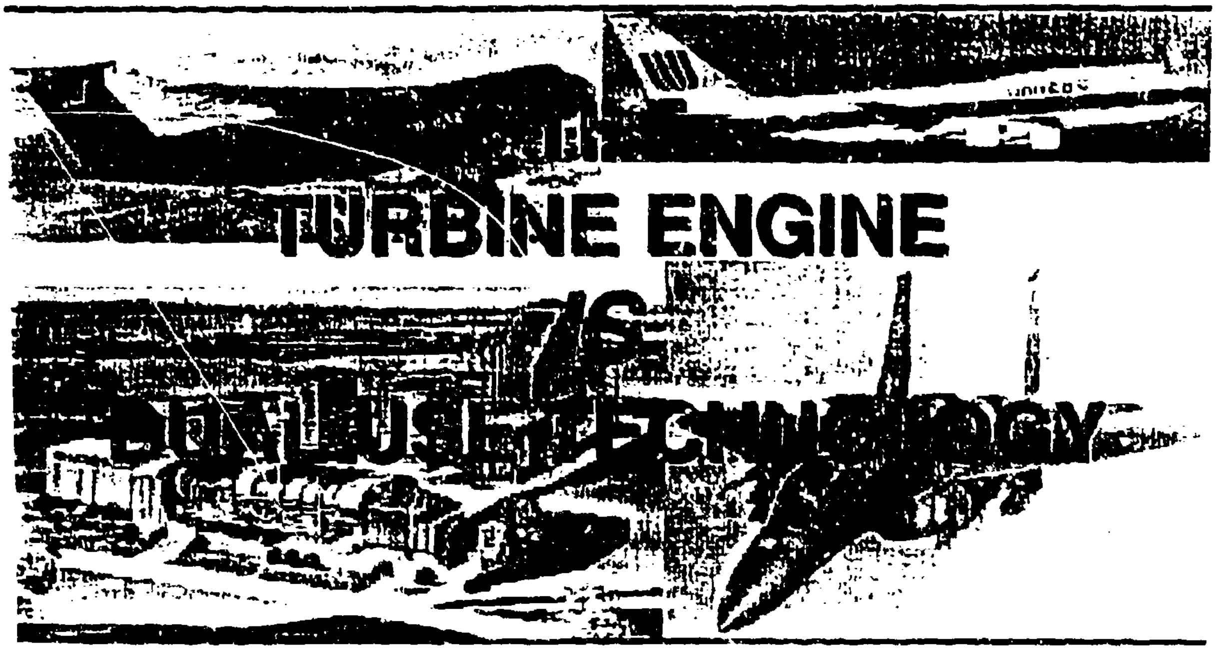

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Aerospace Materials and Processes Technology Reinvestment Workshop

Structural Ceramics (Cont)

DOD Uses (Cont):

- Hot Aerostructure (Hypersonics, Exhaust Impinged Structure)
- Armor
- Space Structures
- Rocket Propulsion
- Wear Parts

Non-DOD Uses:

- Gas Turbine Engines
  - Aeropropulsion
  - Auxiliary Power Units
  - Automotives
  - Land Based Power Generation
- Reciprocating Engines
  - Automotives
- Hot Aerostructure
- Heat Recovery Systems
- Burners, Combustors
- Chemical Process Equipment
- Dies, Tooling
- Wear Parts
- Cutting Tools, Shears

Metal and Ceramic Material Processing

Mr. James Morgan
Metal and Ceramics Division

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Aerospace Materials and Processes
Technology Reinvestment Workshop

Process Modeling Technology

Process Modeling Technology for the Design of Processes to Produce Metallic and Ceramic Components

- **Why Ready?**

– Widely Used Proven Technology

  - Forging
  - Extrusion
  - Rolling
  - Casting

- **Unique Features**
  - Finite Element Based Computer Models
  - Applicable to Complex Geometries and Advanced Materials
  - Material Behavior Models
  - Fluid Flow

- **Current/Future Uses:**
  - DOD Use: Advanced Propulsion Systems
Advanced Airframe Systems
Space Systems
  - Non-DOD Use: Commercial Aerospace
Automotive
Machine Tool
Space

Aerospace Materials and Processes
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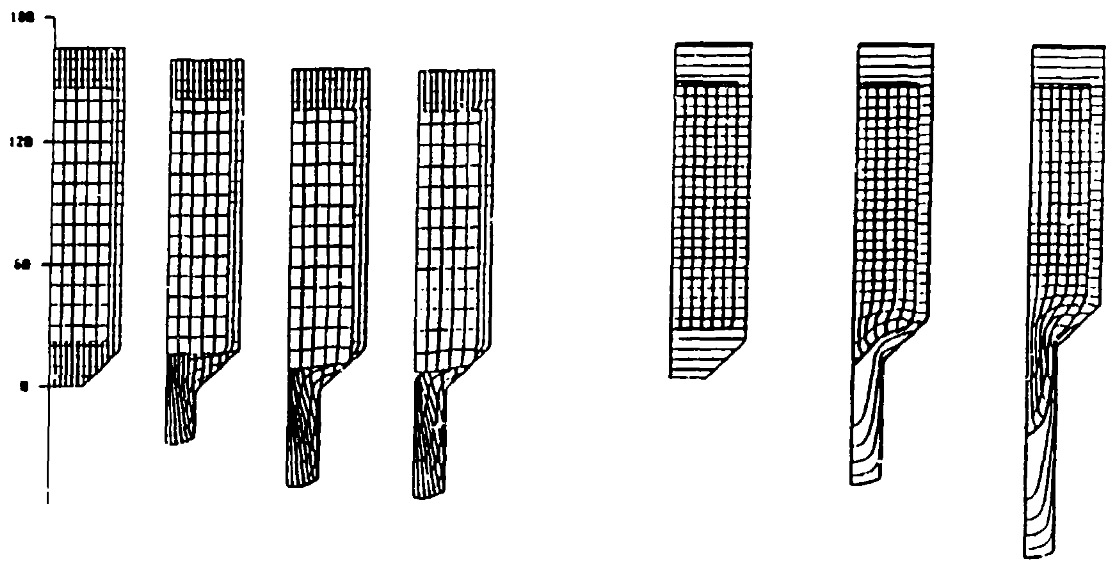
Processing Science Methodology

- **Analytical Modeling**
  - Deformation
  - Densification
  - Solidification
  - Fluid Flow
- **Material Behavior Modeling**
  - Processing Maps
  - Constitutive Equations
- **Physical Modeling**
  - Visioplasticity
  - Pilot-Scale Production

FEM SIMULATION OF CANNED EXTRUSION OF GAMMA TITANIUM ALUMINIDES

Wright Laboratory — **Materials Directorate**

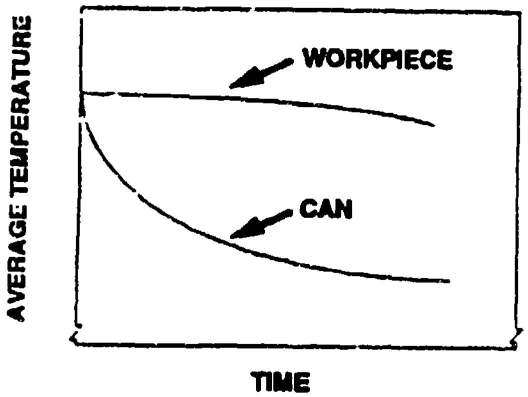


Initial Billet and Can Temperatures Assumed to be Equal

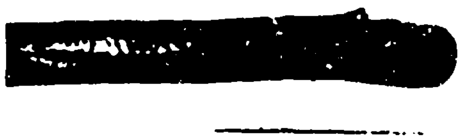
Initial Can Temperature Assumed to be 200°C Lower Than Billet Temperature

THE CONTROLLED DWELL EXTRUSION PROCESS

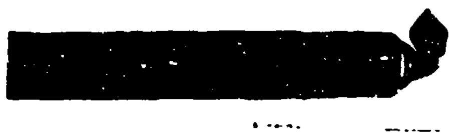
Wright Laboratory — **Materials Directorate**



Temperature Transients Within Can and Workpiece Prior to Extrusion



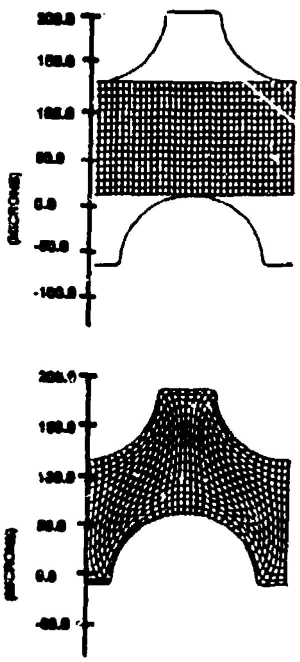
"Conventionally" Extruded Gamma Billet

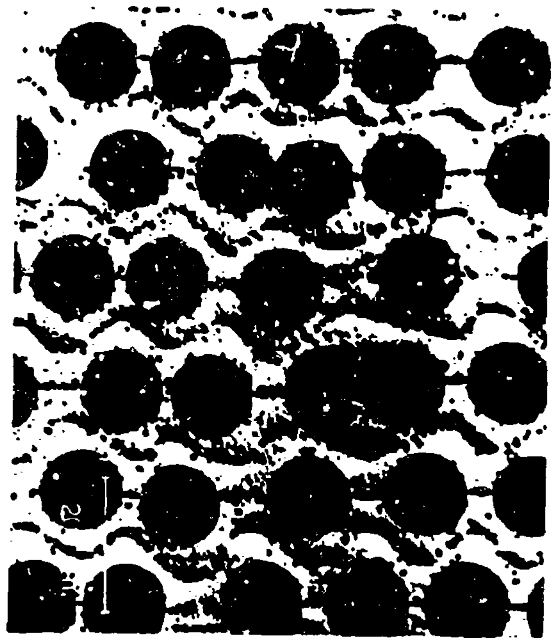


"Controlled Dwell" Extruded Gamma Billet

FINITE ELEMENT MODEL OF FOIL-FIBER-FOIL COMPOSITE CONSOLIDATION

Wright Laboratory | **Materials Directorate**





WRIGHT LABORATORY
MATERIALS DIRECTORATE
EXPERIMENTAL MATERIALS PROCESSING LABORATORY (EMPL)

700-Ton Extrusion Press

MISSION: Provides materials processing expertise and leadership for the large scale introduction of new aerospace materials.

FACILITIES:
8,000 Sq. Ft.
8 On-site Personnel
Arc and TIG Welding
Heat Treating
Data Acquisition Support
Process Modeling
Casting

EQUIPMENT:
Arc and Induction Melters
1000 Ton Forging Press
700-Ton Extrusion Press
Rolling Mill

AVAILABILITY: Available, at nominal cost, to government, industrial and academic organizations.

PAYOFFS

- ELIMINATE COSTLY EMPIRICAL TRIAL-AND-ERROR PROCESS DEVELOPMENT
- PRODUCE COMPLEX SHAPE COMPONENTS WITH REQUIRED MICROSTRUCTURE AND PROPERTIES
- PROVIDE A RATIONAL STRATEGY FOR PROCESS CONTROL AND REPRODUCIBLE QUALITY
- PROVIDE U.S. INDUSTRIES WITH TECHNOLOGY TO PRODUCE HIGH QUALITY COMPONENTS AT THE LOWEST POSSIBLE COST AND TO COMPETE IN THE GLOBAL MARKET

Aerospace Materials and Processes
Technology Reinvestment Workshop

Key Personnel

Metals and Ceramics Material Processing Key Personnel:

Mr. James Morgan - Experimental Materials Processing, Modeling
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Dr. Lee Semiatin - Processing Science Methodology
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Nondestructive Evaluation

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NDE Dual-Use

NDE IS INHERENTLY DUAL-USE

- INDUSTRIAL
- CIVIL AIRCRAFT / FAA
- MEDICAL

STRONG CUSTOMER PULL

Aerospace Materials and Processes
Technology Reinvestment Workshop

NDE Exploratory & Advanced Development

DIRECTIONS

4-1 Aging Systems NDE
- Hidden Corrosion Characterization
- Detection of Innerlayer Cracks Under Fasteners

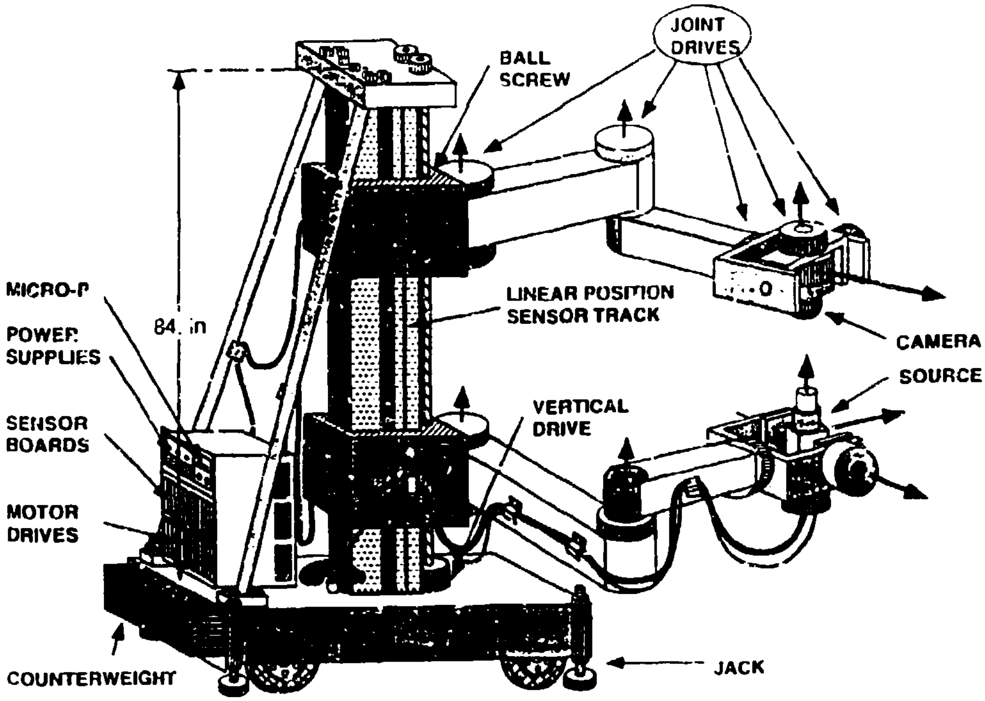
4-2 NDE Reliability Improvement
- Advanced Filmless, Real Time Radioscopy
- Advanced Computed Tomography

4-3 Composite Materials and Processes NDE
- Large Area Composites NDE System Development
- In-Process NDE for Composite Processing

4-4 Advanced Materials and Processes NDE
- Complex, Cast Blade NDE
- Image Enhancement / Analysis

HRRTR BRASSBOARD SYSTEM CONCEPT

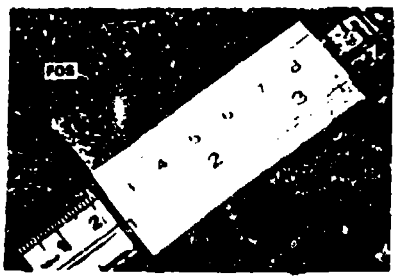
Lockheed



INDUSTRIAL QUALITY INC

1991 R&D 100 AWARD FOR HIGH-RESOLUTION GLASS X-RAY DETECTORS

Lockheed



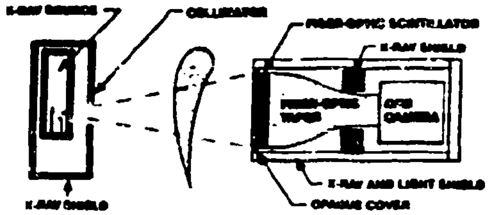
NEW GLASS FABRICATED INTO FIBERS AND MADE INTO FIBER-OPTIC SCINTILLATING (FOS) FACEPLATE

GLASS FEATURES

- HIGH-DENSITY, HIGH Z YIELDS IMPROVED X-RAY ABSORPTION
- HIGH SPATIAL RESOLUTION
- LOW AFTERGLOW

APPLICATIONS

- IMPROVED INDUSTRIAL AND MEDICAL X-RAY IMAGING
- MEASUREMENT OF DIMENSIONS OF INTERNAL STRUCTURE
- VERIFICATION OF NEW FABRICATION TECHNOLOGY



FOS FIBER COUPLED TO CCD CAMERA

FATIGUE CRACK AT FASTENER IN C-130 HERCULES. CRACK WIDTH, <0.001 in., CRACK LENGTH, 0.090 in. IMAGE OBTAINED WITH NEW GLASS USING FOS/CCD SYSTEM. THIS CRACK WOULD NOT BE DETECTED USING NDT X-RAY FILM.

X-ray
Computed Tomography
Research Facility

- OPERATIONAL AIRCRAFT NEEDS
  - Rapid NDI for Advanced Composites with Complex Shapes and Variable Densities
- INCREASED USE OF COMPOSITES (C-17, 777)
  - Unique Inspection Requirements
  - Large Areas
  - Primary Structure - Mission Critical
- COMPOSITE REPAIRS
  - POST REPAIR INSPECTION REQUIRED

High Resolution Real-Time X-Ray Radioscopy

High Resolution Real-Time X-Ray Radioscopy

- Ready for Transition

  Advanced Development hardware being developed

  FY94 Demo planned of developmental system

- Current / Future Uses

  Department of Defense

  - Replace film radiography
  - Field / Depot Use

  Non-DOD

  - Civil Aircraft Inspection
  - Medical
    - Mammography
    - Dental

X-ray Computed Tomography

X-ray Computed Tomography

- Ready for Transition

  Advanced development applications program finishing FY93
  Cost advantages demonstrated - reported

- Current / Future uses

  Department of Defense

  - Inspect castings, closed systems
  - Depot use, airframe, solid rocket motors

  Non-DOD

  - Castings
  - Medical
    - Advanced Mammography
  - Automotive

AIR FORCE INTEREST IN COMPUTED TOMOGRAPHY (CT)

Payoff?

- Higher performance designs
- Improved manufacturing
- Reduced maintenance and repair costs
- Extended equipment life

Rockets

AF is currently using CT

- nozzles
- propellants
- bondlines

Aircraft

Structures, Materials, Equipment

- product development
- process monitoring
- manufacturing inspection
- inservice inspection

MLB

Dr Charles E. Browning
Nonmetallic Materials Division

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45433-7750

Aerospace Materials and Processes
Technology Reinvestment Workshop

Agenda

- Division Overview

- Key Personnel for Technology Transfer

- Topics for Technology Transfer
  - Structural Materials Branch - MLBC
  - Nonstructural Materials Branch - MLBT
  - Mechanics & Surface Interactions Branch - MLBM
  - Polymer Branch - MLBP

Aerospace Materials and Processes
Technology Reinvestment Workshop

Corrosion Prevention Methods

Corrosion Prevention Methods
The need for materials/processes to manage corrosion of aircraft systems continues to be top priority. Introduction of substitutes has been driven by environmental, health, and safety issues.

Why ready? 1) Current regulations reduce/eliminate the use of past, proven materials including inhibitors, platings, solvents, etc., 2) Qualification of acceptable substitutes needed immediately, 3) drop-in substitutes rare.

What are the unique features? 1) Applicable to numerous uses, 2) supplier/user vested interest.

What are current/future uses?
Dual Use - Qualified acceptable substitutes applicable to commercial aircraft, automotive industry, medical devices, etc.

POC: MR. GARY STEVENSON
WL/MLSA (513) 255-5108

CORROSION CONTROL (CON'T)

- ON-GOING EFFORT TO "QUALIFY" ACCEPTABLE SUBSTITUTES
  - AEROSPACE INDUSTRY/SUPPLIERS/TRI-SERVICE/CO-OPERATION
  - QUALIFICATION VIA ACCELERATED LABORATORY EVALUATION
  - FIELD/SERVICE EVALUATION TO OBTAIN "TEST-OF-TIME" IS A LUXARY
  - RARELY SEE EQUIVALENT PERFORMANCE IN ACCELERATED TESTING
  - DROP-IN SUBSTITUTES ARE RARE
  - UNKNOWN LONG-TERM AEROSPACE PERFORMANCE

CORROSION

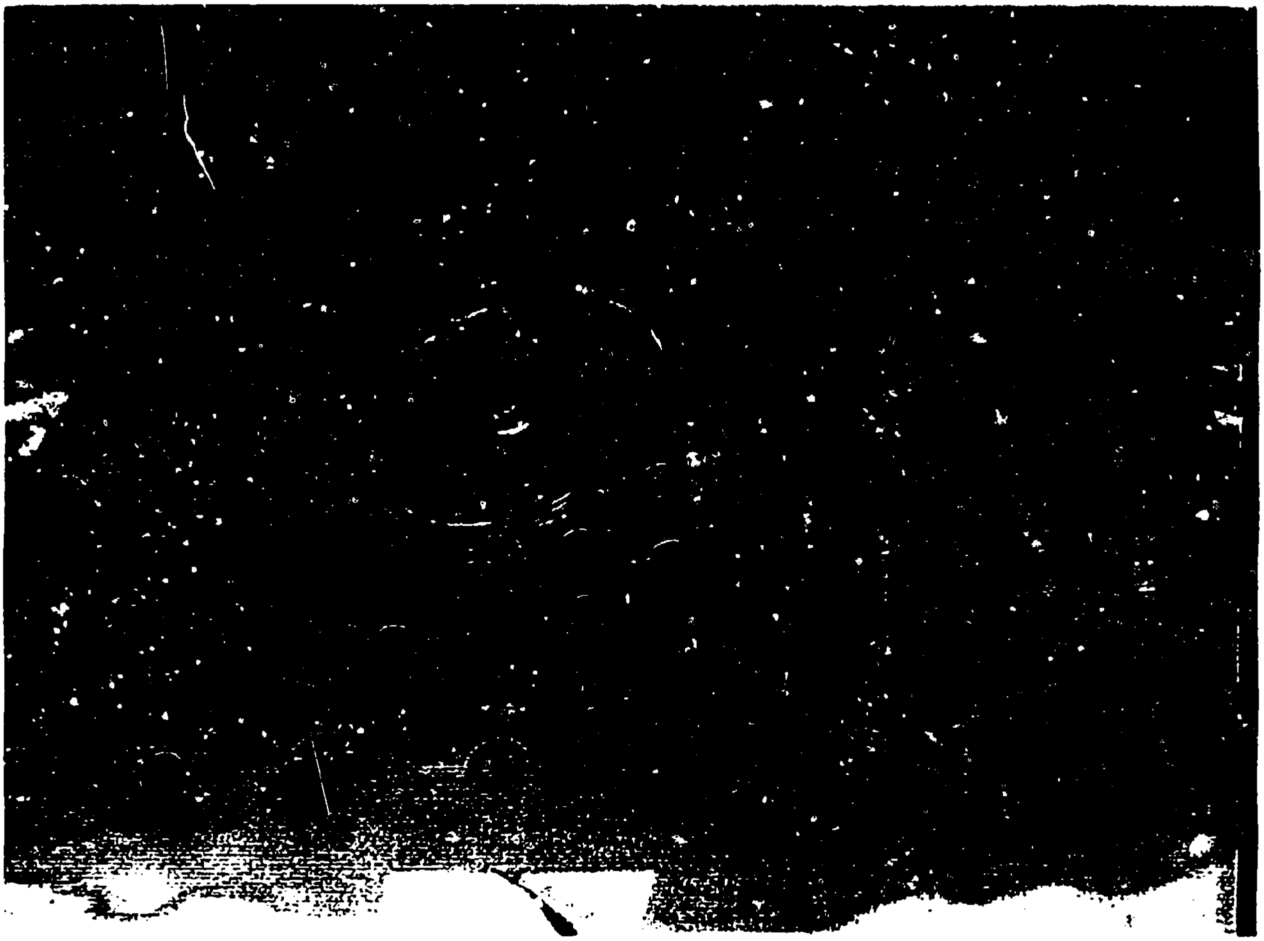
CORROSION CONTROL

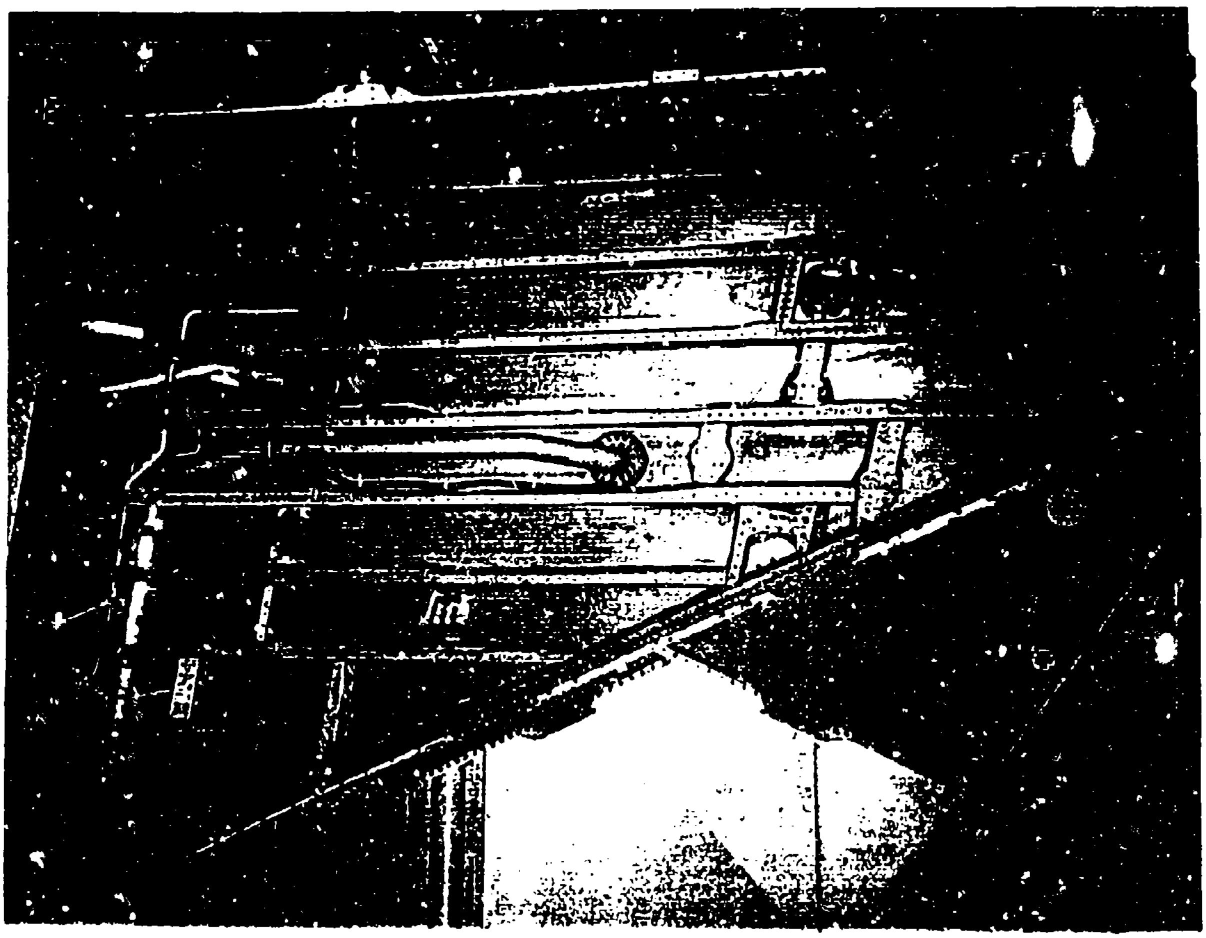
•ENVIRONMENTAL, HEALTH, SAFETY ISSUES

- REPLACE PROVEN CORROSION CONTROL MATERIALS/PROCESSES
- PROVEN MATERIALS REFORMULATED TO LOWER PERFORMANCE LEVELS

•EVER-CHANGING REGULATIONS IMPACT

- HEXAVALENT CHROMINUM INHIBITORS
- HEAVY METAL PLATINGS
- OZONE DEPLETING & GLOBAL WARMING CHEMICALS
- COATING AND SEALANT REMOVAL/REPLACEMENT
- SOLVENT - BORNE COATINGS





PROGRAM ACTIVITIES

- COMPOSITE REPAIR OF CRACKED ALUMINUM STRUCTURES
  - MATERIAL AND PROCESS ISSUES RELATED TO COMPOSITE PATCH APPLICATION IN A FIELD ENVIRONMENT
  - SEVEN TASKS
  - INITIATED WHEN STATE OF THE ART PATCHING WAS DEFICIENT

F-16 PATCH REPAIR

- CRACK AROUND FUEL VENT HOLE ON LEFT WING LOWER SKIN
- SYSTEM SUPPORT TECHNICAL CONTRIBUTIONS
  - SELECTED SURFACE PREPARATION, ADHESIVE, AND PATCH MATERIALS
  - DEVELOPED APPLICATION PROCEDURES
  - APPLIED PATCHES TO F-16 AIRCRAFT AT HILL AFB UT
- OUTYEAR PLAN TO APPLY ADDITIONAL COMPOSITE PATCHES ON OTHER CRACK PRONE F-16 AIRCRAFT AREAS
- TWENTY MILLION DOLLAR COST SAVINGS ACROSS F-16 FLEET USING COMPOSITE PATCHES VERSUS DESKINNING

Composite Materials Patch/Repair Activities

COMPOSITE MATERIAL PATCH REPAIR ACTIVITIES FOR AGING AIRCRAFT

- F-16 WING
- B-1 LONGERON
- KC-135 KEEL BEAM
- B-52 WING

Electronic Failure Analysis

TECHNOLOGY TRANSITION

Fuel Probe Failure Analysis Prevents Possible Grounding of T-37 Aircraft Fleet

NEED: Eliminate potential safety hazard caused by improperly functioning fuel probes on T-37 aircraft.

APPROACH: ML analysis of failed fuel probes revealed a materials degradation process between the fuel probes' silver plated wiring and residual sulfur in jet fuel.

Recommended improved fuel probe design and new maintenance procedures.

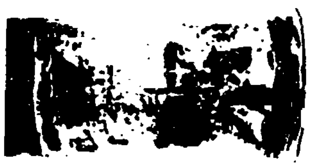
APPLICATION: Using ML recommendations, San Antonio ALC engineers effectively managed the fuel probe problem without having to ground the aircraft.

Structural Failure Analysis

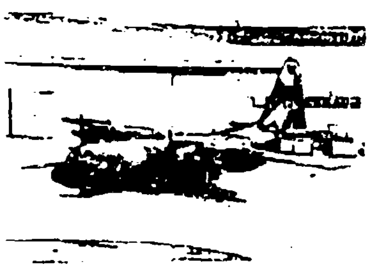
WRIGHT LABORATORY

MATERIALS DIRECTORATE

BLEED AIR DUCT FAILURE ANALYSIS IDENTIFIED ROOT CAUSE FOR C-130 SAFETY OF FLIGHT ISSUE



M L S A



NEED: ELIMINATE BLEED AIR DUCT FAILURES WHICH WERE A SOURCE FOR FLIGHT CONTROL SYSTEM FAILURE.

APPROACH: ML ANALYSIS DETERMINED THAT 321SS DUCT MATERIAL WAS BEING DEGRADED AS A RESULT OF IMPROPER WELDING DURING MANUFACTURE.

APPLICATION: ML TRANSISTIONED INSPECTION PROCEDURES TO KEEP THE FLEET OPERATIONAL. ML RECOMMENDATIONS FOR MATERIAL SUBSTITUTE AND PROCESS IMPROVEMENTS AS A LONG TERM FIX ADOPTED.

Aerospace Materials and Processes
Technology Reinvestment Workshop

AGENDA

- Current activities within the Systems Support Division supporting aging aircraft
  - Structural failure analysis of C-130 bleed air ducts
  - Electronic failure analysis of T-37 fuel probes
  - Composite patch repair activities
- Corrosion prevention methods

Aerospace Materials and Processes
Technology Reinvestment Workshop

Aging Aircraft

Aging Aircraft
A large segment of the Air Force operational fleet is aged and deteriorated to the point where major refurbishments and retrofits are required to continue use.

Why ready? 1) Life extensions a requirement, 2) the development of new systems in the near term will be minimal, 3) mission requirements likely to be increased.

What are the unique features? 1) Environment/mission/material driven, 2) applicable to numerous systems including trainers, bombers, and fighters, 3) needed are improved inspection methods for corrosion and flaw detection, improved repair methods, etc.

What are current/future uses?
Dual Use - system enhancements applicable to commercial fleet.

POC: MR. RON WILLIAMS
WL/MLSA (513) 255-3623

Aerospace Materials and Processes
Technology Reinvestment Workshop

Pollution Prevention R&D

POLLUTION PREVENTION R&D

The ML pollution prevention R&D program is focused on the elimination of water, VOC and ODC waste streams. Through the development and transfer of advanced materials and processes the Air Force will eliminate these waste streams from the manufacture and maintenance of its weapon systems

Major thrusts:
- Non chemical metal surface preparation
- VOC compliant coating systems
- Super critical CO2 cleaning
- Non-TOX/HAZ anti-ice/de-ice for aircraft
- Advanced fire extinguishing materials

Potential Payoff:
- Eliminate the use of bad acting materials
- Improve health/safety of workers
- Processes used universally by industry

THESE ARE NEW FY93 PROJECTS

POC: TED J. REINHART
WL/MLSE (513) 255-3691

Aging Aircraft and Corrosion Prevention Methods

Mr. Ronald H. Williams, Chief
Materials Integrity Branch
Systems Support Division

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TWO MECHANISMS FOR COOPERATIVE R&D BETWEEN INDUSTRY & DOD (AIR FORCE)

- DUAL USE TECHNOLOGY DEVELOPMENT PROJECTS (DARPA)
- COOPERATIVE RESEARCH & DEVELOPMENT AGREEMENT (CRDA)
  - POTENTIAL AREAS OF INTEREST

    ADVANCED COATING & REMOVAL TECHNOLOGY
    REMOVAL HIGH PERFORMANCE COATINGS
    NON CHROME CORROSION INHIBITING SYSTEMS (NON-LEAD, CADMIUM TOO)
    ADVANCED CONVERSION COATINGS
    ADVANCED FIRE EXTINGUISHING/EXPLOSION SUPPRESSION

WRIGHT LABORATORY

POLLUTION PREVENTION PROGRAMS

MATERIALS DIRECTORATE (ML)

ADVANCED METAL SURFACE TREATMENT PROCESSES

OBJECTIVE: TO REPLACE EXISTING WET CHEMISTRY PROCESSES FOR PREPAINT / PREBOND SURFACE PREPARATION OF ALUMINUM & COPPER ALLOYS

APPROACH: R&D INVESTIGATIONS INTO:
- THIN FILM DEPOSITION TECHNOLOGY
- THERMAL SPRAY TECHNOLOGY
- SOL-GEL OXIDE FILM DEPOSITION
- ION-BEAM ENHANCED FILM DEPOSITION

PAYOFF:
- ELIMINATES LARGE WATER CONTAMINATING/USING PROCESSES
- ELIMINATES USAGE OF STRONG ACIDS AND BASES
- ELIMINATES USAGE OF SOLUBLE CHROME

WL POLLUTION PREVENTION R&D

ADDITIONAL STUDY AREAS

- ADVANCED PRINTED CIRCUIT BOARD PROCESSES
- ELIMINATION OF WATER BASE METAL DEPOSITION & REMOVAL PROCESSES
- TURBINE ENGINE OIL RECYCLING
- SOLID STATE METAL CLEANING PROCESSES
- ENVIRONMENTALLY ACCEPTABLE "CHAFF" MATERIALS
- ENVIRONMENTALLY ACCEPTABLE BATTERIES (NiMH)

POLLUTION PREVENTION R&D

WRIGHT LABORATORY AREAS OF FOCUS

- o WATER WASTE STREAM ELIMINATION
- o VOLATILE ORGANIC COMPOUNDS (VOCS) ELIMINATION
- o SOLID WASTE STREAM ELIMINATION
- o OZONE LAYER DEPLETING SUBSTANCES (OLDS) ELIMINATION

WL POLLUTION PREVENTION R&D

6Aug92

o WATER WASTE STREAM ELIMINATION

- NON CHEMICAL BASE SURFACE TREATMENTS FOR Al, Ti & Cu ALLOYS FOR BONDING & COATING

  FORMATION OF THERMODYNAMICALLY STABLE SURFACE MORPHOLOGIES

  THIN FILM DEPOSITION, SOL GEL TECHNIQUES HIGH VELOCITY OXYGEN FUEL, FLAME/PLASMA SPRAY LASER BASE PROCESSES

- ADVANCED PAINT STRIPPING TECHNOLOGY

  ROBOTICALLY CONTROLLED PROCESSES PLASTIC MEDIA, WATER, CO2

ILIP ENVIRONMENTAL THRUSTS

- o FOUR MAJOR USAF ACTIVITIES
  - RISK ANALYSIS
  - CLEANUP, SITE RESTORATION
  - COMPLIANCE, EXISTING TECHNOLOGY
  - PREVENTION, FUTURE TECHNOLOGY

6 Aug 92

POLLUTION PREVENTION R&D

APPROACH

- o ELIMINATE THE SOURCES (i.e., EMPTY THE PIPELINE)
- o QUANTUM IMPROVEMENTS (LEAP FROG TECHNOLOGY)
- o WORK THE DIFFICULT, LONGER TERM, HIGH PAYOFF OPPORTUNITIES

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Topics for Technology Transfer

1. Pollution Prevention
POC: Mr. Ted Reinhart (513) 255-3691

2. Aging Aircraft
POC: Mr. Ron Williams (513) 255-2623

3. Corrosion Prevention Methods
POC: Mr. Gary Stevenson (513) 255-2623

Pollution Prevention
Research & Development

Mr. Ted J. Reinhart
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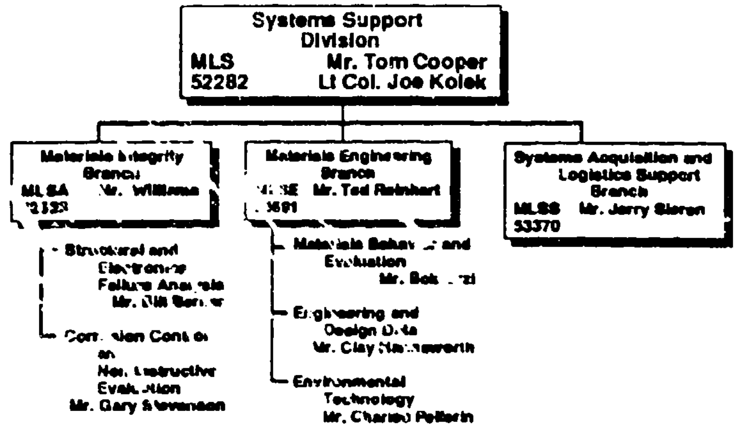
MLS Division Overview



Aerospace Materials and Processes
Technology Reinvestment Workshop

Key Personnel

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Materials Integrity Branch
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Mr. Gary Stevenson
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Materials Engineering Branch
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Mr. Bob Urzi
Materials Behavior & Education
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Mr. Clay Harmsworth
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Mr. Charles Pellerin
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Mr. Jerry Sieren
Systems Acquisition & Logistics Support Branch
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MLS

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Aerospace Materials and Processes
Technology Reinvestment Workshop

Agenda

- Systems Support Division Overview
- Key Personnel for Technology Transfer
- Topics for Technology Transfer

Aerospace Materials and Processes
Technology Reinvestment Workshop

Mobile Automated Scanner

Large Area Composite Inspection - Mobile Automated Scanner

- **Ready for Transition**

Advanced Development hardware being developed
Already being used on real aircraft components

- **Current / Future Uses**

Department of Defense

- Large radome inspection
- C-17 composites inspection

Non-DOD

- Civil Aircraft Inspection - Boeing 777
- Infrastructure
  - Pipes
  - Large Composite Tanks

Aerospace Materials and Processes
Technology Reinvestment Workshop

Key Personnel

Nondestructive Evaluation Key Personnel:

Mr Charles Buynak - Digital Radioscopy, Ultrasonics
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Phone#: 513-255-9807

Mr Tobey Cordell - NDE Technology
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Dr Thomas Moran - NDE Research
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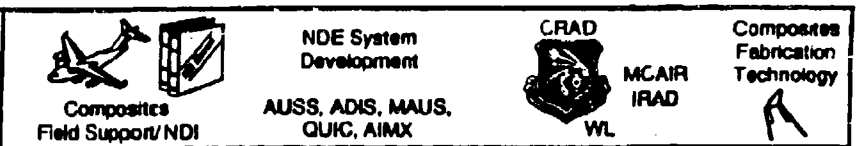
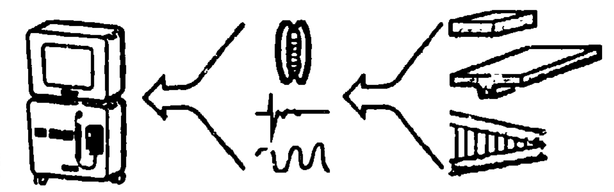
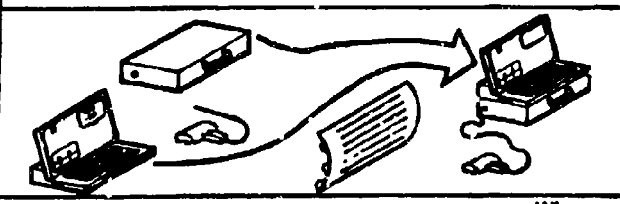
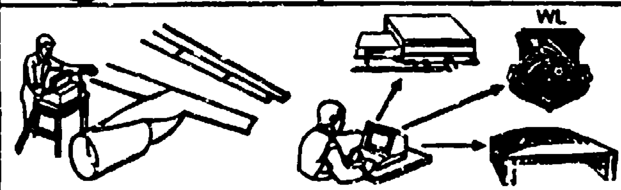
Phone#: 513-255-9806

WL/MLLP / MCAIR — LACIS

Program Overview

Previous Work Foundation		
Task I Breadboard		**Features** • Existing Equipment/ Materials • Proven Concepts • Evaluation • Optimization • Prototype Concept Refinement • Customer Review
Task II Prototype Development/ Evaluation		• Component Design • Component Development/ Procurement • System Integration • Large Area Evaluation • Continual Improvement • Customer Review
Task III Full-Scale Inspection System Model Design/ Validation		• Prototype Refinement • Field Hardening • Validation • Demonstration

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MLB DIVISION OVERVIEW

CHIEF
C. E. Browning

ASSISTANT CHIEF
G. F. Schmitt

SDI MATLS & STRS
G. G. Ormbrek
- STRL MTLS
- LU S
- ADAPTIVE STRS
- SE

POLYMER BRANCH
T. E. Helminiak
MLBP
- ORDERED POLYMER (OP) FIBERS & FILMS
- CONDUCTING POLYMERS
- NONLINEAR OPTICAL POLYMERS

MECHANICS & SURFACE INTERACTIONS BRANCH
L. S. Theibert
MLBM
- MECHANICS OF COMPOSITES
- SURFACE PHYSICS & CHEMISTRY
- THIN FILM MAT'LS AND PROCESSES

STRUCTURAL MATERIALS BRANCH
J. N. Garrison
MLBC
- STRUCTURAL COMPOSITES
- CARBON-CARBON COMPOSITES
- COMPOSITES PROCESSING

NONSTRUCTURAL MATERIALS BRANCH
K. J. Eisentraut
MLBT
- FLUIDS
- LUBRICANTS
- COATINGS
- TRIBOLOGY

Aerospace Materials and Processes Technology Reinvestment Workshop

Key Personnel

<u>Nonmetallic Materials Division</u>

Dr. Charles E. Browning, Chief, 513-255-9018, FAX 513-255-9019

Mr. George F. Schmitt, Assist Chief, 513-255-9018. FAX 513-255-9019

<u>Space Materials and Processes</u>

Mr. Glenn G. Ormbrek, 513-255-2199, FAX 513-255-2176

<u>Polymer Branch - MLBP</u>

Dr. Ted E. Helminiak, 513-255-9158, FAX 513-255-9019

<u>Structural Materials Branch - MLBC</u>

Mr. Jan N. Garrison, 513-255-9070, FAX 513-476-4706

<u>Nonstructural Materials Branch - MLBT</u>

Dr. Kent J. Eisentraut, 513-255-5731, FAX 513-255-9019

<u>Mechanics and Surface Interactions Branch - MLBM</u>

Mr. L. Scott Theibert, 513-255-3068, FAX 513-476-4706

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Structural Materials Branch

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Technology Transfer Topics

Structural Materials Branch

- Carbon-carbon composites for electronic packaging
- Carbon-carbon composites for brakes/clutches
- Carbon-carbon composites as graphite replacement
- Carbon-carbon composites for space structures or thermal management
- Advanced Composites for Infrastructure
- Light Weight, Low Cost Composites for Automotive Applns
- High Temperature Organic Composites for Industrial, Automotive Applns
- Smart Materials & Structures for Infrastructure, Transportation
- Composites for Offshore Petroleum Operations

Aerospace Materials and Processes
Technology Reinvestment Workshop

C-C COMPOSITES FOR ELECTRONIC PACKAGING

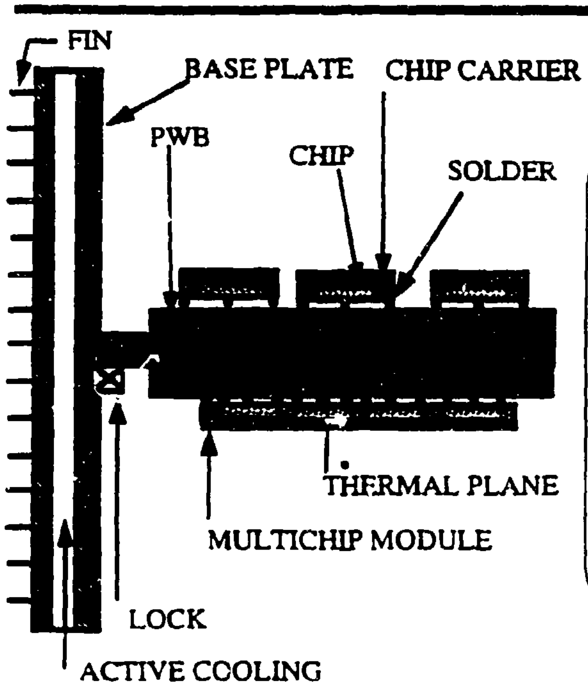
- <u>Why is this ready for transition?</u>
  - Concept has been demonstrated
  - Low cost options available
- <u>What are the unique features?</u>
  - Very high thermal conductivity
  - Low, tailorable coefficient-of-thermal-expansion (CTE)
  - Metallic & ceramic coatings/plating developed/demonstrated
- <u>What are current/future uses:</u>

  <u>Department of Defense</u>
    - Thermal planes, heat sinks, heat sink fins
    - Multichip module (MCM) & PWB substrates
    - Matched chip/substrate CTE
    - Thermally conductive tie-down for components

  <u>NON-DOD</u>
    - Same as Department of Defense
- <u>Point of Contact:</u> Ken Davidson, WL/MLBC, 513-255-9067

Aerospace Materials and Processes
Technology Reinvestment Workshop

C-C COMPOSITES FOR ELECTRONIC PACKAGING



ELECTRONIC PACKAGING

- C-C potential to reduce with increased heat dissipation
- 1500 SEM E boards on advanced aircraft, C-C thermal planes save 540#
- NAWC estimates 100# weight savings = $25 million savings over the lifetime of the F-14 fleet
- Tailorable expansion with hybrid C-C/Al/C-C
- Enhanced operational reliability, MIL handbook 217D indicates MTBF lifetimes increases from 3000 hrs at 167 °F to 7000 hrs at 130 °F

Aerospace Materials and Processes Technology Reinvestment Workshop

ADV COMPOSITES FOR INFRASTRUCTURE

- WHY READY FOR TRANSITION:
  - STRUCTURAL APPLICATIONS SINCE MID 1960'S
  - MATERIAL/MFG DATA BASE, INDUSTRIAL BASE
- UNIQUE FEATURES
  - WEIGHT SAVINGS
  - TAILORABLE PROPERTIES
  - CORROSION/FATIGUE RESISTANCE
- CURRENT/FUTURE APPLICATIONS:
  - DOD: - AEROSPACE STRUCTURES
    - MARINE STRUCTURES
  - NON DOD: - SPORTING GOODS
    - MEDICAL EQUIPMENT
    - INFRASTRUCTURE
- POINT OF CONTACT: JAN GARRISON, WL/MLBC, 513-255-9070

Aerospace Materials and Processes Technology Reinvestment Workshop

LIGHTWEIGHT, LOW COST COMPOSITES FOR AUTOMOTIVE

- WHY READY FOR TRANSITION:
  - STRUCTURAL APPLICATIONS SINCE MID 1960'S
  - MATERIAL/MFG DATA BASE, INDUSTRIAL BASE
  - MAJOR DOD, NASA COST REDUCTION ACTIVITY
- UNIQUE FEATURES
  - WEIGHT SAVINGS
  - EASE OF ASSEMBLY/REPAIR
  - LOW MAINTENANCE COST
  - CORROSION/FATIGUE RESISTANCE
  - ENERGY ABSORBING
- CURRENT/FUTURE APPLICATIONS:
  - DOD: - AEROSPACE STRUCTURES
    - MARINE STRUCTURES
  - NON DOD: - SPORTING GOODS
    - MEDICAL EQUIPMENT
    - INFRASTRUCTURE
    - AUTOMOTIVE
- POINT OF CONTACT: JAN GARRISON, WL/MLBC, 513-255-9070

Aerospace Materials and Processes Technology Reinvestment Workshop

HIGH TEMP OMC'S FOR INDUSTRIAL & AUTOMOTIVE APPLNS

- WHY READY FOR TRANSITION:
  - USAF DEVELOPMENT PROGRAM SINCE 1988
  - ENGINE, AIRFRAME STRUCTURES
  - CURRENT FLIGHT TESTING
- UNIQUE FEATURES
  - WEIGHT SAVINGS
  - HIGH TEMPERATURE CAPABILITY (700°F)
  - CORROSION/FATIGUE RESISTANCE
- CURRENT/FUTURE APPLICATIONS:

  DOD: - AIRCRAFT & ENGINE STRUCTURES

  NON DOD: - ELECTRONICS
  - AUTOMOTIVE (UNDER THE HOOD, EXHAUST)
  - INDUSTRIAL (POWER GENERATORS, ENGINES)
  - COMMERCIAL AIRCRAFT ENGINES
- POINT OF CONTACT: JAN GARRISON, WL/MLBC, 513-255-9070

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SMART MAT'LS & STRUCTURES FOR INFRASTRUCTURE, TRANSPORTATION

- WHY READY FOR TRANSITION:
  - AEROSPACE INDUSTRY AND GOVERNMENT ACTIVITY SINCE '80'S
  - CURRENT SPACECRAFT/ AIRCRAFT TESTING AND DEMOS
  - CIVIL ENGINEERING APPLICATIONS (JAPAN, EUROPE)
- UNIQUE FEATURES:
  - ABILITY TO SENSE VIBRATIONS, STRAINS
  - STRUCTURAL LIFE MONITORING
  - ABILITY TO ACTIVELY CONTROL, DAMP VIBRATIONS
- CURRENT DOD RESEARCH AND DEVELOPMENT
  - AIRCRAFT/SPACECRAFT/SUBMARINE STRUCTURES
  - INTELLIGENT PROCESSING
- NON-DOD APPLICATIONS
  - AUTOMOTIVE
  - ACOUSTIC NOISE CONTROL FOR CABIN INTERIORS
  - EARTHQUAKE-PROOF BUILDINGS
  - BRIDGES
  - OIL TANKERS, PRESSURE VESSELS
- POINT OF CONTACT: JAN GARRISON, WL/MLBC, 513-255-9070

Aerospace Materials and Processes
Technology Reinvestment Workshop

COMPOSITES FOR OFFSHORE PETROLEUM OPERATIONS

- WHY READY FOR TRANSITION:
  - STRUCTURAL APPLICATIONS SINCE MID 1960'S
  - MATERIAL/MFG DATA BASE, INDUSTRIAL BASE
  - MAJOR DOD, NASA COST REDUCTION ACTIVITY
- UNIQUE FEATURES
  - HIGH STRENGTH/STIFFNESS-TO-WEIGHT
  - FATIGUE/CORROSION RESISTANCE
  - ACOUSTIC, VIBRATION & ENERGY ABSORPTION
  - PROCESSABLE IN VERY LONG, CONTINUOUS LENGTHS
- CURRENT/FUTURE APPLICATIONS:

  DOD:
  - AEROSPACE STRUCTURES
  - MARINE STRUCTURES

  NON DOD:
  - SPORTING GOODS
  - MEDICAL EQUIPMENT
  - INFRASTRUCTURE
  - AUTOMOTIVE
- POINT OF CONTACT: JAN GARRISON, WL/MLBC, 513-255-9070

Aerospace Materials and Processes
Technology Reinvestment Workshop

Key Personnel

Fluids, Lubricants, Tribology, Seal and Coating Materials

Mr Carl E. Snyder, Jr.
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Phone #: 513-255-9036

MLBT

Nonstructural Materials Branch

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Aerospace Materials and Processes Technology Reinvestment Workshop

Topics for Technology Transfer

Nonstructural Materials Branch

- Nonflammable Hydraulic Fluid
- Fire Resistant Hydraulic Fluid
- Electronic Coolant
- Cooperative Specialty Fluid & Lubricant Development
- Self-Lubricating Aluminum Metal Matrix Composites
- Ceramic Bearing Technology
- Diamond Coated Ball Bearings
- Pulsed Laser Deposition Technology

Aerospace Materials and Processes Technology Reinvestment Workshop

Nonflammable Hydraulic Fluid MIL-H-53119

Why is it ready for transition?

- A fully formulated hydraulic fluid, including the base fluid, antiwear additive and a rust inhibitor, has been developed. Validation in flight-worthy components with compatible elastomeric seals has been successfully completed

What are unique features?

- The only truly nonflammable hydraulic fluid operating from -65°F to 350°F

Future uses include

- DOD (currently in R&D programs)
  - US Army ground vehicles
  - Air Force brake systems
  - Electric hydraulic actuators (EHA's)
- Non-DOD
  - Mining
  - Rapid transit, etc.

Point of Contact: C. E. Snyder, Jr., WL/MLBT/WPAFB/ 513-255-9036

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Fire Resistant Hydraulic Fluid MIL-H-87257

Why is it ready for transition?

- Developed as a replacement for flammable MIL-H-5606, this fluid has been successfully validated in the B-1 simulator

What are its unique features?

- This fluid is the only drain-and-fill replacement for the very flammable hydraulic fluid that will operate down to -65°F for cold start applications

Uses : DOD : This fluid will replace MIL-H-5606 in former SAC aircraft

Non DOD : Small commercial aircraft; industrial equipment

Point of Contact: C. E. Snyder, Jr., WL/MLBT, WPAFB 513-255-9036

Aerospace Materials and Processes Technology Reinvestment Workshop

Electronic Coolant
PAO Coolant

Why is it ready for transition?

- This coolant has been successfully used since 1987 in the B-1 aircraft and since then has been converted to use in many DOD systems including Patriot missile, LANTIRN radar system and the F-18

What are its unique features?

- This non-reactive PAO coolant replaces a troublesome silicate ester coolant that reacted with water causing a gel and a flammable alcohol.
- One-fourth the cost of the old coolant

Uses:

- DOD
  - Currently in many applications, future uses are in all systems using silicate ester coolants and some using silicone oils
- Non-DOD
  - Solar heat transfer fluid for energy savings

Point of Contact: Lois Gschwender, WL/MLBT/WPAFB 513-255-7530

Aerospace Materials and Processes Technology Reinvestment Workshop

Cooperative Specialty
Fluid &Lube Development

Why is it ready for transition?

- Specialty Fluid and Lubricant Development has successfully led to the development and transition of a wide variety of materials, - Fire resistant and nonflammable hydraulic fluids, PAO coolants, specialty greases, gas turbine lubricants

What are its unique features?

- This technology can be directly applied to non-DOD requirements, e.g., lubricants for new refrigeration systems, specialty fire resistant fluids and lubricants, replacements for mineral oil based products that are no longer available, etc.

Point of Contact: C. E. Snyder, Jr.WL/MLBT, WPAFB 513-255-9036

Aerospace Materials and Processes Technology Reinvestment Workshop

SELF-LUBRICATING ALUMINUM METAL MATRIX COMPOSITES

Why is this ready for transition?

- Long term friction tests (1M cycles) demonstrated self-lubricating nature
- Steady state friction coefficient <.05 (dry) and <.1 (>50% humidity)

What are its unique features?

- Extremely low wear rates; Smearing of Al eliminated
- Lightweight (<3 g/cc) with tailorable mechanical properties

USES: DOD : Self-lubricating bearing material for use in vacuum, dry and moist environments

Non DOD : Self-lubricating lightweight metal-based bearing material

Point of Contact: K. R. Mecklenburg, WL/MLBT WPAFB 513-255-2465

Aerospace Materials and Processes Technology Reinvestment Workshop

CERAMIC HYBRID BEARING TECHNOLOGY

Why is it ready for transition ?

- Ceramic materials provide advanced performance in demanding ball and roller bearing applications

What are its unique features?

- Ceramic balls in steel races can provide long life and reduced wear

Uses:

- DOD : Ball bearings for precision gimbals, turbine engines and for high and low temperature operation in air and vacuum
- Non DOD : Spindles for machine tools; corrosion resistant operation using ceramic balls and races; high vacuum; high speed and high and low temperature operation

Point of Contact: Karl R. Mecklenburg, WL/MLBT, WPAFB 513-255-2465

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PLD of Thin-Film Tribological Materials

Why is it ready for transition?

- R&D for Deposition Technology Complete; Ready for Scale-up and Commercialization

What are its unique features?

- Low Temperature Deposition; Extraordinary Film Properties, Environmentally Friendly Process

Uses:

- DOD : High Temperature Turbine Engine Components; Ball Bearings, Races, Gimbals, etc.; Space-borne components.
- Non DOD : Ball Bearings, Races, Components requiring solid lubrication/ hard coatings, etc

Point of Contact: Dr. M. S. Donley, WL/MLBT, WPAFB 513-255-6485

Aerospace Materials and Processes Technology Reinvestment Workshop

DIAMOND COATINGS CERAMIC BEARINGS

Why is it ready for transition?

- Developmental Research Completed; Ready for Commercialization

What are its unique features?

- Diamond is the Hardest Material Known; Excellent Microstructure and Surface Finish; Excellent Heat Conductor

Uses:

- DOD : Ball Bearings for Precision Applications (Gimbals, Sensors); High Temperature Corrosive Atmosphere Operations; Limited Lubricant Operations
- Non DOD : Precision Bearings for Long Life, e.g., Dental Drills; Corrosive Environments; High Speed Operations: Limited Lubricant Availability

Point of Contact: Dr. M. S. Donley, WL/MLBT, WPAFB 513-255-6485

MLBP

Polymer Branch

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Aerospace Materials and Processes
Technology Reinvestment Workshop

Topics for Technology Transfer

MLBP Topics for Technology Transfer:

- **High Temperature Organic Electro-Optic Materials**
- **High Temperature Thermoplastic Polymers**

Aerospace Materials and Processes Technology Reinvestment Workshop

Key Personnel

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513 255-9139

Dr. Seng Tan - Structural Polymers
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Mr. Bruce Reinhardt - Organic Electro-Optic Materials
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Aerospace Materials and Processes Technology Reinvestment Workshop

High Temperature Thermoplastic Polymers

Why is it ready for transition?

- Reproducible Synthesis Process

What are the unique features?

- High Use Temperature (Up to 450°F max.)
- Low Dielectric Properties (Good Insulator)
- Environmental/Moisture Resistant (Less Swelling, Good Arc Resistance)
- Tailorable Mechanical/Thermal Properties
- Some Polymers Amenable To Spin Coating-Type Technologies

Current/Future Uses:

DOD
- New High Temperature Canopy/Sensor Material
- Kapton Wire-Wrap Replacement
- Dielectric Insulator For Electronic Packages
- Thermal Barrier
- Matrix Phase for Electro-optic Polymers

NON DOD
- Sensors
- Wire insulation
- Electronic Packaging

POC: Marilyn Unroe (513) 255-9145

Aerospace Materials and Processes Technology Reinvestment Workshop

High Temperature Organic Electro-Optic Materials

<u>Why is it ready for transition?</u>

- These materials offer a substantial improvement in properties over state-of-the-art, second-order, organic electro-optic materials

<u>What are the unique features?</u>

- Large 2nd-Order Activity
- High transparency at visible light wavelengths
- Increased Thermal Stability
- Low dielectric constant

<u>Current/future Uses:</u>

<u>DOD</u>

- Increased recording capacity for CD's via laser light manipulation
- Higher density of interconnects using E-O materials
- Improved thermal management of electronic devices

<u>NON-DOD</u>

Same as above

<u>POC:</u> Bruce Reinhardt WL/MLBP (513) 255-9162

MLBM

Mechanics & Surface Interactions Branch

513-255-3068
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Aerospace Materials and Processes Technology Reinvestment Workshop

Technology Transfer Topics

Mechanics & Surface Interactions Branch

- GaAs Materials and Processing Technology
- Hard Coating Materials and Processing Technology
- Molecular Beam Epitaxy Processing Science and Control
- Characterization of Materials Surfaces and Thin Films
- Real Time Damage Monitoring
- Efficient, 3-D, Numerical Methods for Composite Response
  - Micromechanics Including Fracture
  - Laminate Mechanics
- Exact Solutions and Analytical Methods for Composite Materials
  - Baseline Solutions for Complex Problems
- Unique Experimental Capabilities
  - Micro/Macro/Interfacial Failure Modes

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MBE Process Control of Low Temp GaAs

Ellipsometer equipped MBE providing real time process control

Why ready?

- Ellipsometer has been developed providing process control of Low Temperature GaAs deposition at 250°C by controlling the temperature of the As source, stochiometry and growth rate in real time.

What are Current/Future Uses?

- DOD
  - Phased Array Radar
  - Infra Red Detectors for Surveillance
  - High Temperature Electronics
- Potential Future Commercial
  - High Definition TV Components
  - Direct Broadcasting Satellites
  - Ultra High Speed Computers
  - Low Power Consumption Electronic Circuits

Point of Contact: L. Scott Theibert, WL/MLBM, 513-255-3068

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Numerical Methods for Composite Response

Why Ready?

- Highlights of 20 years of research by Dr Pagano and associates at WL/ML have been incorporated in the software package "Automated System for Composite Analysis (ASCA)."
- Basis for user friendly numerical methods to describe composite laminates and predict their response

What are the Unique Features?

- Fiber, matrix, coatings and interface conditions are property inputs
- Micromechanical analysis used to compute moduli of layers with n-directional fibers
- Calculates laminate properties and stresses including interlaminar stresses
- Define stress fields due to free edges, curing, moisture, transverse cracks & debonding

What are Current/Future Uses?

- DOD Uses
  - Design/analysis of solid propellant rocket nozzles
  - Characterization of materials applications for air and space vehicles
- Commercial Uses
  - Composite materials design/selection for infrastructure, sporting goods, etc.
  - Validation of finite element programs/solution

Point of contact: L. Scott Theibert, WL/MLBM, 513-255-3068

MLP

Mr. William R. Woody
Electromagnetic Materials
and Survivability Division

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Aerospace Materials and Processes
Technology Reinvestment Workshop

Agenda

- Division Overview
- Key Personnel for Technology Transfer
- Topics for Technology Transfer

Aerospace Materials and Processes Technology Reinvestment Workshop

MLP Management Team

- CHIEF: MR. WILLIAM R WOODY
- DEPUTY: LT COL DAN CLEYRAT
- CONSULTANT FOR TECH TRANSFER: MR. GORDON GRIFFITH

MLPJ

- HARDENED MATERIALS BRANCH — MR. GARY K WAGGONER
  - LASER HM TECHNICAL AREA — MS SUE KIRCHOFF / DR. ROBERT CRANE I/H LDR
  - AIRBORNE SYSTEMS HDN'G — MS PAM SCHAEFER
  - SPACE SURVIVABILITY — MR DENNIS HAGER

MLPO

- ELECTRONIC AND OPTICAL MATERIALS BRANCH — MR. ROBERT DENISON
  - EM MAT'LS DEVELOPMENT GP — MR. ROB SUSNIK
  - ELECTRONIC AND OPTICAL MAT'LS TECHNOLOGY GP — MR. LYLE G RIFFEE / DR. P. HEMENGER, I/H LEADER

Aerospace Materials and Processes Technology Reinvestment Workshop

Major Thrusts With Potential for Transfer

MLP

MLPJ — HARDENED MATERIALS

- Thin Film Process Monitoring and Control
- New Optical Filters - Rugates
- Bio-derived Optical Films
- Laser R&D Facilities

MLPO — ELECTRONIC AND OPTICAL MAT'LS

- Materials for High Temp Electronics -- SiC
- InP for Electronics and Opto-Electronics
- NLO Materials
- IR Windows
- IR Detectors
- HT Superconductors

Aerospace Materials and Processes Technology Reinvestment Workshop

Topics for Technology Transfer

- Materials for High Temperature Electronics – SIC
- InP for Electronics and Opto-Electronics
- NLO Materials
- HT-SC Materials & Processes
- Thin Film Process Monitoring and Control
- New Optical Filters - Rugates
- Biotechnology for Optical Materials
- Laser R&D Facilities

Aerospace Materials and Processes Technology Reinvestment Workshop

Points of Contact

- Materials for High Temperature Electronics – SIC
  - Mr Tom Kensky
- InP for Electronics and Opto-Electronics
  - Ms Laura Rea
- NLO Materials
  - Dr Ken Hopkins
- HT-SC Materials & Processes
  - Mr Tim Peterson
- New Optical Filters - Rugates
  - Mr Walt Johnson
- Biotechnology for Optical Materials
  - Dr Wade Adams / Dr Robert Crane
- Laser R&D Facilities
  - Mr Rob Hull / Dr Pat Hood / Mr Charles Lovett

Aerospace Materials and Processes
Technology Reinvestment Workshop

Materials for High Temperature Electronics

Materials for High Temperature Electronics – SIC

- A NEW MATERIALS SYSTEM - FOR APPLICATION
- SPECIALTY APPLICATIONS
  - MILITARY - ADVERSE REQUIREMENTS
    - TURBINE ENGINE CONTROLS
    - T/R MODULES FOR 10 GHz
  - COMMERCIAL
    - AUTOMOBILE ENGINE CONTROLS AND SENSORS
    - ADVERSE ENVIRONMENT ELECTRONICS - YOUR CHOICE

POC: Mr. Tom Kensky
WL/MLPO (513)255-4588 Ext. 3218

Aerospace Materials and Processes
Technology Reinvestment Workshop

SiC
Key Personnel

Materials for High Temperature Electronics – SIC

<u>Materials for High Temperature Electronics - SIC Program Manager</u>

Mr Tom Kensky
WL/MLPO Building 651
3005 P Street STE 6
Wright-Patterson AFB, OH 45433-7707
Phone #: 513-255-4474 ext 3249 or 3218

<u>Materials for High Temperature Electronics - Sr Tech Advisor</u>

Dr William Mitchel
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Aerospace Materials and Processes
Technology Reinvestment Workshop

InP for Electronics and Opto-Electronics

InP for Electronics and Opto-Electronics

- InP-based devices can operate at higher power and higher frequency than current SOA GaAs-based devices
- Technology (Bulk and epitaxial) has been demonstrated
  - devices produced, being inserted into systems
- What are current/future uses:

  Department of Defense
  - Opto-electronics for Computing, Terrahertz Communication
  - High-Speed signal processing
  - T/R Radar modules

  NON-DOD (If any or new applications if you have examples)
  - Cellular Communications/Satellite Applications
  - Collision Avoidance Radar (Automotive)
  - GPS Padar

POC: Ms. Laura Rea
WL/MLPO (513)255-4588 Ext. 3213

Aerospace Materials and Processes
Technology Reinvestment Workshop

InP Key Personnel

InP for Electronics and Opto-Electronics

InP for Electronics - Program Manager

Ms Laura Rea
WL/MLPO Building 651
3005 P Street STE 6
Wright-Patterson AFB, OH 45433-7707
Phone #: 513- 255-4474 ext 3213

InP for Electronics - Sr Tech Advisor

Dr William Mitchel
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Aerospace Materials and Processes
Technology Reinvestment Workshop

Nonlinear Optical Materials

Nonlinear Optical Materials

- Materials for New Laser Sources (optical wavelength conversion) and for Electro-Optic Devices (optical wave guides and spatial light modulators)
- APPLICATIONS
  - Department of Defense
    - Electro-Optic Countermeasures
    - LIDAR
    - Laser Radar
    - Optical Signal Processing (eg. target recognition)
    - Optical Interconnects for Electronic Pkgs
  - NON-DOD (If any or new applications if you have examples)
    - LIDAR
    - Medical Lasers
    - Switching Networks for Communications
    - Optical Interconnects for Electronic Pkgs
    - Scientific Instruments

POC: Dr. Ken Hopkins
WL/MLPO (513)255-4588 Ext. 3219

Aerospace Materials and Processes
Technology Reinvestment Workshop

Key Personnel

Nonlinear Optical Materials

Overall Program

Dr Ken Hopkins
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Inhouse Characterization and Materials Growth

Dr David Zelmon
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Aerospace Materials and Processes
Technology Reinvestment Workshop

Superconducting Materials & Processes

High Temperature Superconducting Materials & Processes

- A NEW MATERIAL - THIN FILMS HAVE DEMONSTRATED POTENTIAL FOR SIGNIFICANT PERFORMANCE ENHANCEMENT
- APPLICATIONS
  - Military
    - Rf circuits for electronic warfare
    - Signal processing
    - IR detectors
  - Commercial
    - Biomagnetic imaging
    - Nondestructive evaluation
    - Passive components for communication satellites
    - Signal processing
    - Multichip modules

POC: Mr. Tim Peterson
WL/MLPO (513)255-4588 Ext. 3235

Aerospace Materials and Processes
Technology Reinvestment Workshop

Key Personnel

High Temperature Superconducting Materials & Processes

<u>Characterization and Applications</u>

Mr. Tim Peterson
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<u>Thin Film Growth</u>

Dr. Rand Biggers
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Aerospace Materials and Processes
Technology Reinvestment Workshop

Innovative Optical Materials

Innovative Optical Materials

Development of Novel Materials for Optical Applications

- Biomolecular materials for NLO films
- Liquid crystal siloxane polymers
- Fullerene-based optical limiting solutions
- Photochromic films for laser dosimetry

Develop molecular materials that are easily tailorable for specific optical applications - low optical thresholds, high speed response, transparent

Current/Future Uses:

DoD
- Laser Protective Visors
- Electro-optic Sensor Protection

NON-DoD
- Electro-Optical Devices
- Optical Computing
- Laser Dosimeter Badge

Aerospace Materials and Processes
Technology Reinvestment Workshop

Key Personnel

Biotechnology for Optical Materials

Dr W. Wade Adams
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Wright-Patterson AFB, OH 45433-7702
Phone #: (513) 255-2110 extension 3171

Dr Robert Crane
WL/MLPJ Building 651
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Phone #: (513) 255-2110 extension 3174

Aerospace Materials and Processes
Technology Reinvestment Workshop

New Optical Filters

New Optical Filters - Rugates

- TECHNOLOGICAL READINESS FOR TRANSITION:
  - TEN YEARS OF DOD SPONSORED R&D PROGRESS
  - EXAMPLE FILTERS SURPASSING CURRENT SOA TECHNOLOGY
- UNIQUE FEATURE: UNLIMITED FREEDOM IN THE DESIGN AND MANUFACTURING OF OPTICAL FILTERS
- EXAMPLE CURRENT/FUTURE USES:

DOD
- HIGH POWER LASER MIRRORS
- ELECTRO-OPTIC SENSOR PROTECTION
- TAILORED HIGH PERFORMANCE OPTICAL FILTERS

NON-DOD
- LIGHTWAVE TELECOMMUNICATION TECHNOLOGY

POC: Mr. Walt Johnson
WL/MLPJ (513)255-2110 Ext. 3170

Aerospace Materials and Processes
Technology Reinvestment Workshop

Key Personnel

New Optical Filters - Rugates

Mr Walter Johnson
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Aerospace Materials and Processes
Technology Reinvestment Workshop

Laser Facilities

Laser R&D and T&E Facilities

Use of lasers for materials processing is becoming more prevalent in both DoD and commercial industries. Two state-of-the-art laser test facilities provide opportunities for proof-of-concept testing.

Laser Hardened Materials Evaluation Laboratory (LHMEL)

- Nationally unique carbon dioxide laser test facility producing repeatable high quality beam profiles at powers up to 150 kW on target. Produces beams in both continuous wave and repetitively pulsed mode.

- Current / Future Uses:

  DoD
  - Laser effect on materials
  - Thermal response of materials or components
  - Surface treatment and coating application

  Non-DoD
  - Materials processing (drilling, cutting, welding)
  - Heat treatment or surface treatment - strength enhancement
  - Materials performance testing - simulation of application heat loads

POC: Mr. Rob Hull
WL/MLPJ (513)255-2334 Ext. 3165

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Technology Reinvestment Workshop

Laser Facilities (Cont)

Laser R&D and T&E Facilities (con't)

One Kilowatt Laser Lab

- 1 kW carbon dioxide laser operating in either continuous wave or repetitively pulsed mode. Extremely small spot sizes and CNC table provide precision beam positioning.

- Current / Future Uses:

  DoD
  - Materials response testing
  - Manufacturing technology proof-of-concept testing
  - Susceptibility (damage level) testing

  NON-DOD
  - Materials processing (cutting, drilling, welding)
  - Precision laser machining or engraving
  - Surface treatment for strength enhancement

POC: Dr. Patrick Hood
WL/MLPJ (513)255-2334 Ext. 3168

POC: Mr. Charles Lovett
WL/MLPJ (513)255-2334 Ext. 3161

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Technology Reinvestment Workshop

Key Personnel

Laser R&D and T&E Facilities

Mid-power materials response testing
Mr Rob Hull
Phone No. (513)255-2334, extension 3165

Laser device technology and materials response
Dr Patrick Hood
Phone No. (513)255-2334, extension 3168

Laser performance and experimental set-up
Mr Charles Lovett
Phone No. (513)255-2334, extension 3161

Mailing Address:
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Technology Reinvestment Workshop

MLP Summary

SUMMARY

Where Are We:

- **Defense Reinvestment - We're Still Learning**
- **Dual Use - We're already there - Can add Emphasis**

Where to Go Next:

- **Awaiting More Definitive Guidance**
- **Will be Seeking Guidance**
    - **From Industry - Our Development Partner**
    - **From the Scientific Community**

The Coming Period Promises to be Interesting & Exciting

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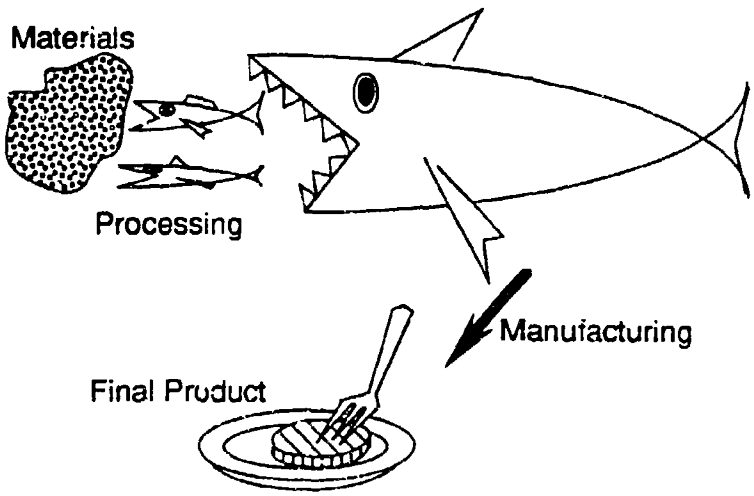
Technology Reinvestment Workshop

Dual Use?

Dual Use	**What Means? - Still Learning**
Defense Reinvestment	**But - For Sure**
Tech Transfer	**- A Paradigm Shift Is Occurring**

- **Dual use is <u>Inherent</u> in the MLP Program**
  - **Materials and Processes Technologies are at the bottom of the food chain**
  - **Most Materials in MLP have/find Alternative Applications in US Tech Base**
- **Past Drivers have been Military Applications only:**
  - **Future Investments Will <u>Consider</u> - Commercial Pull**
  - **Many Options for Inclusion of Dual Use in MLP Program**

MATERIALS ARE AT THE BOTTOM OF TECHNOLOGY FOOD CHAIN



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Past MLP Developments

Past MLP Developments Have Found Commercial Applications

- Rare Earth Permanent Magnet Materials
- Ultra-High Purity Silicon
  - Developed for Laser Seekers and IR Detectors
  - Have found use in:
    - High Power Devices
    - VHSIC
- HgCdTe
  - Developed for Forward Looking IR Systems
  - Commonly Used in
    - Radiometers - lab & Pollution Monitoring
- GaAs Materials for Radar T/R Modules
  - Mandatory for Satellite Communication
    - Direct Broadcast TV
    - Satellite Cellular Phones

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Future Drivers for Dual Use

MLP Future Drivers for Dual Use

- Will Not Abandon Our Classic AF Customers
  - AF Requirements *ARE* Stressing
  - Needed Capability is #1

- However
  - We Will Seek to Add the Commercial Sector to the "Customer" List
    - For Development Activities
  - Will Seek to Add Commercial Requirements / Needs

- As We Do This - We Will "Expect" Development Teams to Share the Commitment & Risk

MLI

Mr Robert L. Rapson
Integration and Operations Division

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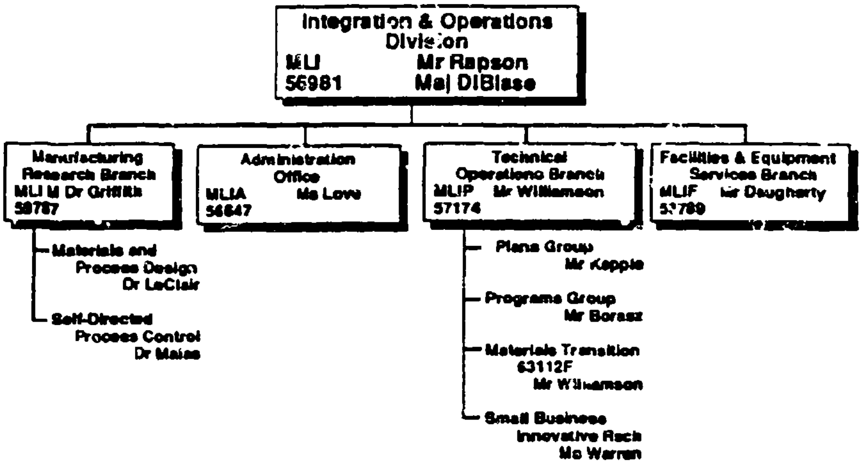
Aerospace Materials and Processes
Technology Reinvestment Workshop

Agenda

- Integration and Operations Division Overview
- Key Personnel for Technology Transfer
- Topics for Technology Transfer

Aerospace Materials and Processes Technology Reinvestment Workshop

MLI Division Overview



Aerospace Materials and Processes Technology Reinvestment Workshop

Key Personnel

Mr. Bob Rapson, Chief
Integration and Operations Division
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Dr. Walt Griffith, Chief
Manufacturing Research Branch
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Dr. Steve LeClair
Materials and Process Design
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Dr. Jim Malas
Self-Directed Process Control
(513) 255-8787 fax 476-7995

Mr. John Williamson, Chief
Technical Operations Branch
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Mr. Gary Kepple
Plans Group
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Mr. Frank Borasz
Programs Group
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Mr. John Williamson
Materials Transition (6.3)
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Ms. Sandy Warren
Small Business Innovative Rsch
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Topics for Technology Transfer

1. Rapid Foundry Tooling System
Integrated Product/Process Design System for Cast Parts
POC: Dr. Steve LeClair, WL/MLIM, (513) 255-8787

2. Rapid Design System
Integrated Product/Process Design for Machined Parts
POC: Dr. Steve LeClair, WL/MLIM, (513) 255-8787

3. QPAL II
Integrated Process Design and Control for Composite Parts
POC: Dr. Steve LeClair, WL/MLIM, (513) 255-8787

4. Innovative Forming Technologies:
NonLinear, Open-Loop Control of Hot Deformation Processes
POC: Dr. Jim Malas, WL/MLIM, (513) 255-8787

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Topics for Technology Transfer (Cont)

5. Deposition Processing Technologies:
Advanced Control Software for Molecular Beam Epitaxy
POC: Oliver Patterson, WL/MLIM, (513) 255-8787

6. Deposition Processing Technologies:
Self-Directed Control Software for Pulsed Laser Deposition
POC: Capt. Elizabeth Stark, WL/MLIM, (513) 255-8787

7. Deposition Processing Technologies:
Self-Directed Control Software of Chemical Vapor Deposition (CVD)
POC: Capt. David Griffin, WL/MLIM, (513) 255-8787

8. Automated Materials Research:
TEM Companion
POC: Dr. Al Jackson, WL/MLIM, (513) 255-8787

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Technology Reinvestment Workshop

Rapid Foundry Tooling System

Rapid Foundry Tooling System
RFTS couples feature-based design and an associative memory to augment pattern making and process planning of mold and pattern (parting line, gates & risers, draft angle, number and location of cores, runners, etc.)

Why ready? Successful prototype implemented at Kelly AFB Foundry available for commercial use or spin-off of enabling technology. Developed and supported by commercial business (AIWARE, Inc., Cleveland, OH) and built on top of their software product called CADChem™.

What are the unique features? 1) Three dimensional associative mapping of part and casting geometry to processing problems to causes. 2) an algorithm (patent applied for) to automatically core a pattern.

What are current/future uses?
Dual Use - pattern making for sand casting, pattern making for investment casting, pattern making for rubber molding.
Non-DoD - pattern making for medical prosthesis.

POC: DR. STEVE LeCLAIR
WL/MLIM (513) 255-8787

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Technology Reinvestment Workshop

Rapid Design System

Rapid Design System
RDS couples feature-based design and a deductive-inductive memory to augment the machinist in process planning of fabrication and inspection of machined parts and enables the system to automate numerical control and coordinate measurement machine code generation.

Why Ready? Prototype implementation at the Developmental Manufacturing and Modification Facility (DMMF) at Wright-Patterson AFB and available for commercial use or spin-off of enabling technology. Developed and supported by commercial business (Technosoft, Inc., Cincinnati, OH) and built on top of their software product called CHISELS™.

What are the Unique Features? Self-improving process design system (patent pending) to augment designer/machinist in optimizing product and process (fabrication and inspection) design.

What are Current/Future Uses?
Dual Use - product/process design for machined parts, automatic fab plan, automatic inspection plan, set up configuration, and product/data exchange (STEP/PDES) standards.

POC: DR. STEVE LeCLAIR
WL/MLIM (513) 255-8787

Aerospace Materials and Processes
Technology Reinvestment Workshop

QPAL II

QPAL II
Qualitative Process Automation Language (QPAL) is a knowledge base methodology and supporting language for the control of dynamic, event-driven processes.

Why ready? Base technology implemented at Sacramento Air Logistics Center and at several commercial sites including Lockheed (formerly General Dynamics), and Honeywell. Original QPAL™ prototype product developed by Air Force and currently supported through (Lawrence Associates, Inc., Dayton, OH) QPAL II is being built on OPAL™ with significantly enhanced language and user interface.

What are the unique features? 1) Event-driven process development and control system (patent awarded), 2) applicable to any non-linear, sensor-based control environment, 3) supports process planning and optimization.

What are current/future uses?
Dual Use - product/process design for composite curing, product/process design for any non-linear, sensor-based materials or product manufacturing process, broadly applicable to overall manufacturing process scheduling and control, applicable to other event-driven scenarios, not limited to manufacturing (e.g., routing, scheduling, order/inventory tracking and control, etc.).

POC: DR. STEVE LeCLAIR
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Aerospace Materials and Processes
Technology Reinvestment Workshop

Self Directed Control of Deformation Processes

Nonlinear, Open-Loop Control of Hot Deformation Processes
(Forging, Extrusion and Rolling) - Optimal Control System Design For Producing Net-Shape Components having Controlled Microstructures and Properties.

Why Ready?
1) Material Behavior and Process Models involved have been experimentally verified.
2) With only partial implementation, some metal working industries are reporting 15 - 25% increase in productivity (e.g. Youngstown Al Extruder's Consortium)
3) P[illegible]ed and current process control technologies could impact a wide range of metal working processes.

What are the Unique Features?
1) Practical process engineering tool, 2) Control system design includes robustness and performance analyses, 3) Especially applicable to complex geometric shapes and difficult-to-process materials.

What are Current/Future Uses?
Dual Use - Design of optimal control systems for deformation processes including forging, rolling, and extrusion; advanced control technology; hierarchical control strategies; sensor fusion, processing of difficult-to-process materials (intermetallics); improved processing efficiencies.

POC: DR. JIM MALAS
WL/MLIM (513) 255-8787

Aerospace Materials and Processes
Technology Reinvestment Workshop

Advanced Control Software for MBE

Advanced Control Software for Molecular Beam Epitaxy - Improved control of thin-film composition and thickness is obtained via real-time control using advanced sensor technology and model based control of the flux.

Why Ready? Successful prototype has been tested at the Air Force Materials Directorate. Patent application has been submitted.

What are the unique features? 1) Automated process identification. 2) Shutter opening flux transient compensation. 3) Adaptive gain/bandwidth control. 4) An artificial neural network is used for quick reduction of ellipsometry data. 5) The control system is easy to understand and adjust.

What are current/future uses?
Dual Use - Control of processes for deposition of electronic materials; improved electronic devices; compositional control; thickness control; advanced sensors; sensor fusion.

POC: OLIVER PATTERSON
WL/MLIM (513) 255-8787

Aerospace Materials and Processes
Technology Reinvestment Workshop

Self-Directed Control Software for PLD

Self-Directed Control Software for Pulsed Laser Deposition (PLD)
Produces high quality solid lubricants and hard coatings through real time control of system parameters.

Why Ready?
Control and monitoring of composition and microstructure during thin-film growth with PLD has been demonstrated.

What are the unique features?
1) High energy process gives good substrate adhesion.
2) Stochiometric growth of material without thermal damage to substrate (20 - 200° C).
3) Environmentally safe.
4) Easy to operate.

What are current/future uses?
Dual Use - Control of processes for deposition of solid lubricants; high temperature precision mold adherence reduction (1040SS Teflon molds for laser surgery); machine tool industry hard coatings (mill and tool ends); gas turbine clearance control; vacuum lubricant applications (disk drives, robotics).

POC: CAPT. ELIZABETH STARK
WL/MLIM (513) 255-8787

Aerospace Materials and Processes
Technology Reinvestment Workshop

Self-Directed Control of CVD

Self-Directed Control of Chemical Vapor Deposition - Produce high quality fiber coatings with desired interface properties for fabrication of ceramic matrix composites.

Why Ready? Planned and current process control technologies could impact a wide range of commercial coating applications.

What are the unique features? 1) Control of deposition morphology allows desired fiber properties 2) High purity, low internal stress coatings.

What are Current/Future Uses?
Dual Use - Control of depositon processes for coating ceramic fibers; ceramic matrix composites; deposition of thermal barrier coatings.

This is a New Project for FY93

POC: CAPT. DAVID GRIFFIN
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Aerospace Materials and Processes
Technology Reinvestment Workshop

Automated Materials Research: TEM Companion

Automated Materials Research: TEM Companion
A memory-driven automated system for analyzing materials using electron microscopy and the crystal structure of the material; the system is coupled to an electron diffraction pattern simulator and uses a crystallography knowledge base.

Why Ready?
Prototype developed by Materials Directorate for use in-house and as a product via SBIR Phase II Contract with ThinkAlong Software, Inc.

What are the unique features?
1) Integration of expert system and neural nets; 2) Extensive crystallographic capabilities; 3) Highly efficient material characterization; 4) Sophisticated analyses with fewer experts; 5) Extend life of expensive equipment; 6) Training aid for universities and industry.

What are current/future uses?
Dual Use - Characterization of new materials, extension of this technology to other sophisticated testing equipment, training and simulation.

POC: DR. AL JACKSON
WL/MLIM (513) 255-8787